

Research Branch Directory of Research

1995 - 1996

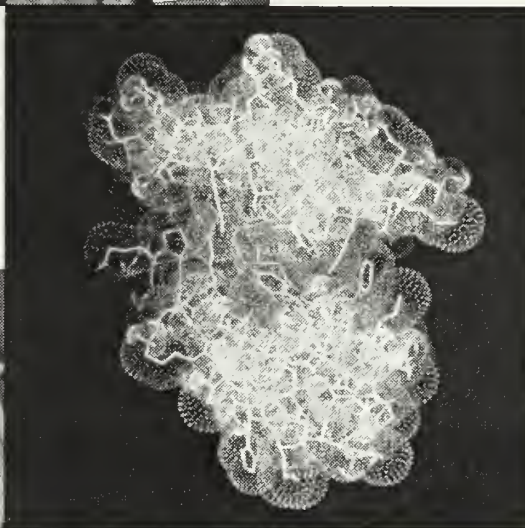
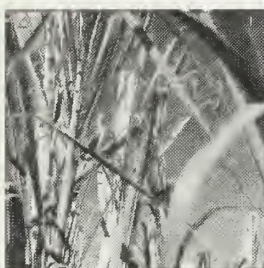


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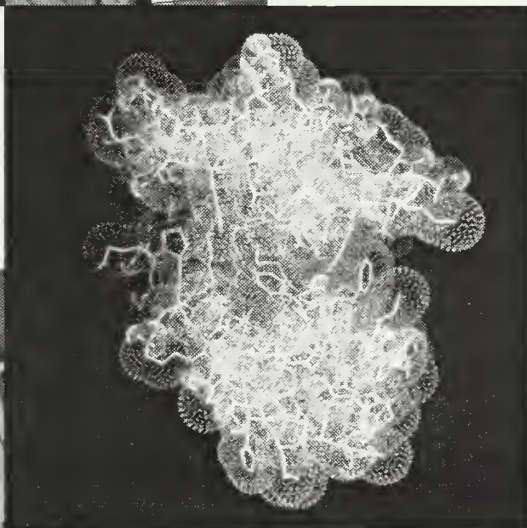


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***Research Branch
Directory of Research***

1995 - 1996



Research Branch

Agriculture and Agri-Food Canada
Publication 5252
1996

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Internet Access

You can **download a copy** of each chapter of this report or the full Directory (**00000** KB) from the Internet, free of charge. It is available as a WordPerfect file.

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RESEARCH BRANCH DIRECTORY OF RESEARCH 1995 - 1996

A Word from our ADM

Welcome to the *Directory of Research*. Here you should find everything you need to link directly to the Research Branch of Agriculture and Agri-Food Canada. It is our hope that producers, businesses, researchers, students, and government officials, nationally and internationally, take advantage of this directory to guide them in their search for information and contacts on our programs, our centres, and our people.

The goal of the Research Branch is to help improve the on-going competitiveness of the Canadian agriculture and agri-food industry. We do this by advancing scientific knowledge and developing and transferring innovative technologies. At the core of our business is basic research aimed at ensuring the long-term safety of our food supply and the health of the environment that produces it. Safety and health are prerequisites for Canada's agriculture and agri-food industry to be competitive and to gain entry to markets. Once these are assured, we can then do research to add value to the industry's products, including the development of nonfood uses for these products.

While basic research is our major focus, we are also eager to put our labs and expertise to work with industry clients on near-market research, with strong commercial applications. That is why Agriculture and Agri-Food Canada created the Matching Investment Initiative. Under this initiative, now in its second year, the Department will match up to one-for-one industry contributions to collaborative research projects. By the year 2000, this program expects to see \$35.8 million of government funding available for matching by industry dollars. Through the Matching Investment Initiative and other collaborative mechanisms, we can ensure that our research priorities accurately reflect the industry's real needs. By involving industry research investors directly, we also help speed up the process of transferring a new technology to the private sector since, in effect, it is pre-sold.

The *Directory of Research*, updated here for 1995–1996, contains the following information on each of our research centres, as well as for Branch headquarters:

- list of staff contacts
- mandate
- main achievements
- resources
- research and departmental publications.

While the Research Branch is now consolidating its activities at 18 centres, you will notice that this edition of the directory includes 20 entries. By April 1997, three of these centres will have been amalgamated with others across the country:

- the Pacific Agriculture Research Centre (Vancouver) will have been consolidated at Summerland
- the Centre for Food and Animal Research will have transferred its staff and program to other centres.

This *Directory of Research* is also available on-line to provide you with better and faster information on our organization and activities. You can find it on ACEIS, Agriculture and Agri-Food Canada's 24-hour Electronic Information Service. For information on how to obtain printed or electronic copies of this publication, please see the instructions on the back of the title page. Again, we hope this directory proves to be a useful guide to the Research Branch for you.

Brian Morrissey, Assistant Deputy Minister, Research
RESEARCH BRANCH DIRECTORY OF RESEARCH 1995 - 1996

Headquarters

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Eastern Region Y.A. Martel, Ph.D.

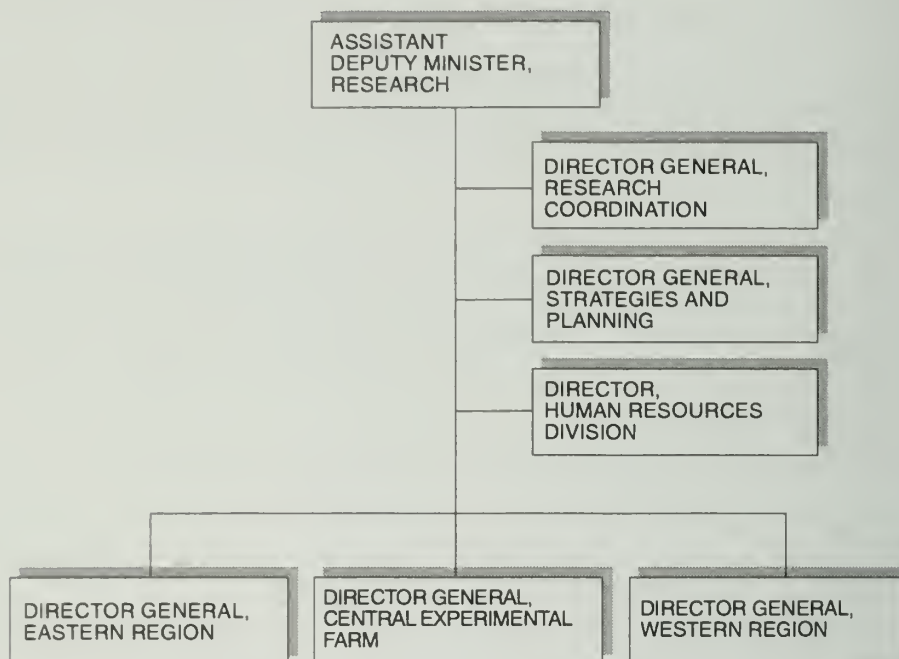
Central Experimental Farm D.G. Dorrell, Ph.D. (acting)

Western Region D.G. Dorrell, Ph.D.

Director, Human Resources Division G. Carpentier, B.A.

RESEARCH BRANCH DIRECTORY OF RESEARCH 1995 - 1996

ORGANIZATION OF THE RESEARCH BRANCH



Research Centres

St. John's	Food and Animals (6)	Cereals
Charlottetown	Eastern Cereal and	Brandon
Kentville	Oilseeds (7)	Saskatoon
Fredericton		Semiarid Prairie Agriculture (8)
Soils and Crops (1)		Lethbridge
Dairy and Swine (2)		Lacombe
Horticulture (3)		Summerland
Food (4)		Pacific Agriculture (9)
Pest Management (5)		
Harrow		

See Map (p. 3) for location of the research establishments keyed by number

MAP OF MAJOR RESEARCH CENTRES



See Organization of the Research Branch (p. 2) for key to the Branch's research centres.

PROGRAMS AT MAJOR RESEARCH CENTRES

			Eastern Region										Central Experimental Farm				Western Region					
			Branch programs																			
	Resources		St. John's	Charlottetown	Kentville	Fredericton	Soils and Crops	Dairy and Swine	Horticulture	Food	Pest Management	Harrow	Food and Animal Research	Eastern Cereals and Oilseeds	Cereals	Brandon	Saskatoon	Semi-arid Prairie Agriculture	Lethbridge	Lacombe	Summerland	Pacific Agriculture
Crops	Land		•		•	•				•	•		•	•	•	•	•	•	•	•		•
	Germplasm / pests & biocontrol				•					•			•	•		•		•				
	Cereals		•		•							•	•	•		•	•	•				
	Oilseeds								•		•	•		•								
	Forages		•	•		•								•	•	•	•		•			
	Field crops						•							•	•	•						
	Vegetables		•	•	•	•		•	•					•				•				
	Tree fruits and berries			•		•									•	•						
	Ornamentals					•			•													
	Animals	Beef		•	•						•		•									
Dairy					•		•															
Swine				•		•						•										
Poultry						•							•									
Other animals											•											
Food	Animal products & processes			•						•												
	Crop products & processes	•		•	•		•			•												
	Nonfood products & processes	•		•	•	•		•														



Agriculture and
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- *About this Publication*
- *Professional Staff*
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- *Achievements*
- *Resources*

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Research Branch

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Mandate

The Research Coordination Directorate ensures a national perspective on the direction of research programs, and the allocation of resources across the Research Branch for special, limited-period programs. The directorate takes the lead, on behalf of the Branch, in

- coordinating research activities, nationally and internationally
- managing issues of national significance that require scientific expertise for resolution
- managing the international file on research-related topics.

Achievements

- ***Branch reviews***
- ***Interdepartmental memorandum of understanding (MOU)***
- ***University grants***
- ***International activities***
- ***Green Plan***
- ***Other special-funded national programs***
- ***Canadian Agri-Food Research Council (CARC)***

Branch reviews The directorate updated the priority list for ongoing studies, and evaluated the probability of success and potential payback for new ones. Staff assisted in the review of research centres and research programs. Several coordinators participated in research scientists' promotion committees.

Interdepartmental memorandum of understanding (MOU) The directorate contributed to the development and implementation of an MOU on research for sustainable development involving the four natural resources departments:

- Agriculture and Agri-food
- Environment
- Fisheries and Oceans
- Natural Resources.

Coordinators are participating in six working groups set up to foster cooperative projects:

- managing R&D priority setting
- climate change and variability
- metals in the environment
- coastal zone management
- renewable energy technologies
- effects of ultraviolet B radiation.

University grants Coordination conducted the annual selection process for grants to universities through the research partnership support program sponsored by the Natural Sciences and Engineering Research Council.

International activities The directorate coordinated or provided support for the following projects on behalf of the Branch:

- the management of Branch-level international agreements to capitalize on the potential of international collaboration in science and technology: a German - Canadian agreement on cooperation in scientific development has been negotiated
- the development of Canada's position on agricultural issues at the Conference of the Parties of the Biodiversity Convention
- the strengthening of collaboration with the Institut national de la Recherche scientifique (INRA), France: 10 research projects involving scientists from both organizations are currently ongoing
- the strengthening of cooperation with the Netherlands Agricultural Research Organization (DLO).

Green Plan As part of the departmental Green Plan initiatives, the directorate coordinated research activities on topics of national relevance. Staff took the lead in reviewing experimental plans and managing the special-program funding attached to initiatives in the areas of

- climate change
- greenhouse gases
- nitrous oxides - volatile organic compounds (NO_x/VOCs)
- genetic resources
- ethanol.

Other special-funded national programs The directorate addressed programs involving

- energy
- food safety
- biotechnology.

In addition, the directorate

- established a working group for integrated pest management (IPM) of the Colorado Potato Beetle and provided leadership in the development of guidelines for the introduction of biocontrol agents against insects and weeds
- managed the liaison with CAB International and its affiliated biocontrol centre at Delemont, Switzerland, and strengthened international collaboration in biological control at the USDA/ARS biocontrol laboratory in Montpellier, France
- provided technical advice to other branches and the new Pest Management Regulatory Agency on issues such as IPM, biological control, and the impact of methyl bromide and other persistent pesticides on the environment
- provided support to the Great Lakes 2000 water-quality research and development program
- represented the Branch on the development of a national strategy on biotechnology
- represented the Branch on the development of a national biodiversity strategy.

Canadian Agri-Food Research Council (CARC) The directorate continued to provide secretariat support to the Canadian Agri-Food Research Council. Staff reviewed and acted on recommendations from regional agricultural coordinating committees and Canada committees.

It provided the secretarial function and liaison to Canada committees on

- resources
- crops
- animals
- food.

Staff also

- chaired the CARC Standing Committee on Biotechnology in Agriculture and Food
- participated in the CARC Standing Committee on the Research Partnership Support Program.

Resources

The Directorate operates with 21 full-time equivalents and a budget of \$1.3 million.



Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

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Mandate

The Strategies and Planning Directorate (S&P) assists the Assistant Deputy Minister and directors general to deliver agri-food research and technology transfer programs. The Branch-wide services S&P provides facilitate

- financial decision-making
- administration
- marketing
- planning.

Achievements

- *Study Management System (SMS)*
- *Matching Investment Initiative*
- *Major Capital Plan*
- *Branch Informatics and Information Systems Committee (BIISC)*
- *Science and technology review*
- *Research Branch Business Plan, 1995 - 2000*
- *Delegation of authority for publishing*
- *ACEIS*
- *BIO '95*
- *AGtran*
- *AGvance*
- *Success Story Database*
- *Publication inventory*
- *Communications*
- *Dialogue with agri-food organizations*
- *Inventory of Canadian Agri-Food Research (ICAR)*
- *Cost recovery module*
- *Pest management information*
- *Commercialization activities*
- *Technology marketing*
- *Intellectual property management*
- *Commercialization workshop*

Study Management System (SMS) The first steps to an integrated approach to information management across the Branch was taken, with the launch of the SMS in November 1995. The SMS facilitates the selection of research studies based on

- probability of success
- payback to the nation
- cost of conducting the research.

It also collects information, tracking approximately 680 studies in progress within the Branch, from inception to the final deliverables. This new tool for the research centres replaces the existing Research Branch Study Data Base. A national profile of research studies will be maintained and updated in a database that will be made available to provide comprehensive information on the Branch's activities.

Matching Investment Initiative This initiative aims to strengthen market-driven priority setting in the Branch and to accelerate the process of technology transfer. The program matches industry dollars on projects that are within the core capability of the Branch. In its first year, S&P developed guidelines and promotional materials to assist research centres establish collaborative arrangements with industry. S&P also proposed a management system for the initiative, including guidelines for in-kind funding. As of March 1996, the Branch has more than 501 collaborative agreements with industry, universities, and other organizations. The industry contribution at the end of March 1996 represented \$13.3 million.

Major Capital Plan A major revision of the 5-year Capital Investment Plan was completed. The Research Branch objective was to identify the changes resulting from the Program Review decisions and to ensure the necessary capital infrastructure to meet research objectives.

Branch Informatics and Information Systems Committee (BIISC) S&P is coordinating Branch efforts to ensure that the planning cycle is well ordered and that the information systems that support it are easy to use and effective. BIISC, with representatives across the Branch, was struck under the leadership of S&P to move forward on these objectives. The aim is to bring continuous improvement to the planning process.

Science and technology review The federal government has completed its review of the way it sets priorities in science and technology. Core research capabilities across the government were looked at and client views were sought. A new government strategy for S&T was launched in March 1996. S&P has developed the departmental response to the review.

Research Branch Business Plan, 1995 - 2000 S&P published a 5-year business plan for the Research Branch, outlining the Branch's strategic approach to R&D and describing its business lines.

Delegation of authority for publishing In September 1995 the Minister signed a delegation of authority from Public Works and Government Services Canada, which allows the Department to undertake its own printing and publishing. The Department now has the right to sell its own information. Revenue from sales going into the consolidated revenue fund can now be recovered under the Department's MOU with Treasury Board.

ACEIS This year S&P succeeded in putting most of its key corporate publications up on ACEIS, Agriculture and Agri-Food Canada's Electronic Information System. ACEIS provides a single window into all of the department's information. Clients can access ACEIS through the Internet, fax, or telephone. On ACEIS you can now find

- *Directory of Research 1994 - 95*
- *Directory of Research 1995 - 96*
- *Research Branch Business Plan 1995 - 2000*
- *AGvance*, a newsletter promoting technology transfer
- *AGran*, a directory of collaborative research opportunities
- Matching investment initiatives brochure
- Research Branch home page, with links into many aspects of the Branch.

BIO '95 The Research Branch participated in the Annual International Biotechnology Meeting and Workshop in San Francisco, to promote collaborative opportunities.

AGran S&P managed and promoted this electronic catalog of technology opportunities in agri-food research.

AGvance This newsletter promoting technology transfer and collaborative arrangements to industry clients was published quarterly. The summer 1995 issue of AGvance made the newsletter's first appearance on the Internet.

Success Story Database The second version of this database, with new features and updated content, was prepared for fall 1994. It continued to be a cornerstone for the Branch's promotional activities.

Publication inventory Industry needs critical information with a comprehensive national perspective from the Branch, to maintain a competitive edge in the marketplace. To meet this need, S&P developed a database on more than 700 of the Branch's publications. This year the inventory was transferred into the Branch's Study Management System. In this format, the centres can input data directly and obtain reports whenever they have a need. The primary aim is to help promote Branch publications to industry clients. But the inventory is also useful for publication planning at the Branch, regional, or establishment level.

Communications Many Research Branch successes were featured prominently in the Department's publications, exhibits, and media tip sheets, and in the Minister's speeches. The Branch took the first steps to establish itself on the Internet. The Branch's home page contains links to home pages of many of the research centres, as well as to Branch publications and databases.

Dialogue with agri-food organizations A good exchange of information is now established with 14 national agri-food organizations. Information about the activities of the Research Branch is forwarded regularly to the national headquarters offices. Selected Research Branch success stories, exhibits, and information brochures are supplied to delegates attending the annual meetings of all organizations during the year.

Inventory of Canadian Agri-Food Research (ICAR) ICAR provides information from all sectors on more than 3500 agri-food research projects in progress. New agreements will provide access to ICAR on Internet via Agriculture and Agri-Food Canada's Electronic Information Service (ACEIS). ICAR is now available on the Farm Business Management Information Network (FBMInet).

Cost recovery module A computerized module is being developed

- to track cost recovery revenue by client, project, and type of service provided
- to produce invoices for clients
- to record payments received
- to upload to AGRIFIN accounts receivable and cash receipts data.

This module of the Micro computerized Management Information Processing System (MMIPS) will also provide on-line enquiry capabilities and printed reports.

Pest management information S&P published pest management information for clients in the agri-food sector through

- *Pest Management News*
- *Canadian Plant Disease Survey*
- *Pest Management Research Report*.

Arrangements were made this year to transfer responsibility for producing these publications to the research community, as part of government restructuring. The Pest Management Research Centre in London, the Expert Committee on Integrated Pest Management, the Canadian Phytopathological Society, and the journal *Phytoprotection* will assume responsibility for various portions of this work next year.

Commercialization activities The Business Initiatives Office (BIO) is the commercialization arm of the Research Branch, facilitating successful collaborations with industry since 1987. Commercialization will continue to bring Branch technologies to the market in a timely manner, adding value to Branch activities by creating alternative sources of funding to support ongoing research. Agreements for the commercialization of Branch research are made to the mutual benefit of all partners. Commercialization promotes the development and transfer of innovative technologies to the marketplace. Funding from commercialization of Branch technologies comes not only from initial contributions but also in the form of royalty payments that help to sustain research programs in the long term.

Technology marketing Marketing efforts were continued on behalf of both the Research Branch and the Food Production and Inspection Branch (FP&I). An updated *Biotechnology Bulletin '95* was prepared, listing over 50 collaborative and licensing opportunities. A promotional brochure was developed for FP&I on diagnostic technologies. Commercialization officers attended trade shows in North America, establishing connections between Branch scientists, entrepreneurs, and the financial community. BIO was invited to give presentations at several prestigious conferences and workshops in North America on technology management, commercialization, and intellectual property protection within the realm of various market sectors, such as biocontrol, diagnostics, venture capital, and the Industrial Research Assistance Program.

Intellectual property management The protection of Branch intellectual property is becoming increasingly important. In addition to the use of Plant Breeders' Rights for variety protection, patenting of technologies including software copyright is becoming more frequent. The protection of Branch intellectual property strengthens the transfer of technology to industry and its subsequent adoption, while ensuring that the Branch obtains a fair financial return for its contribution.

Commercialization workshop BIO hosted a commercialization workshop. Speakers included key representatives from industry, as well as members of the financial and legal communities. Participants included Branch scientists and managers from across Canada. The workshop provided a practical approach to commercialization. Its goal was to familiarize Branch representatives with the commercialization process.

Resources

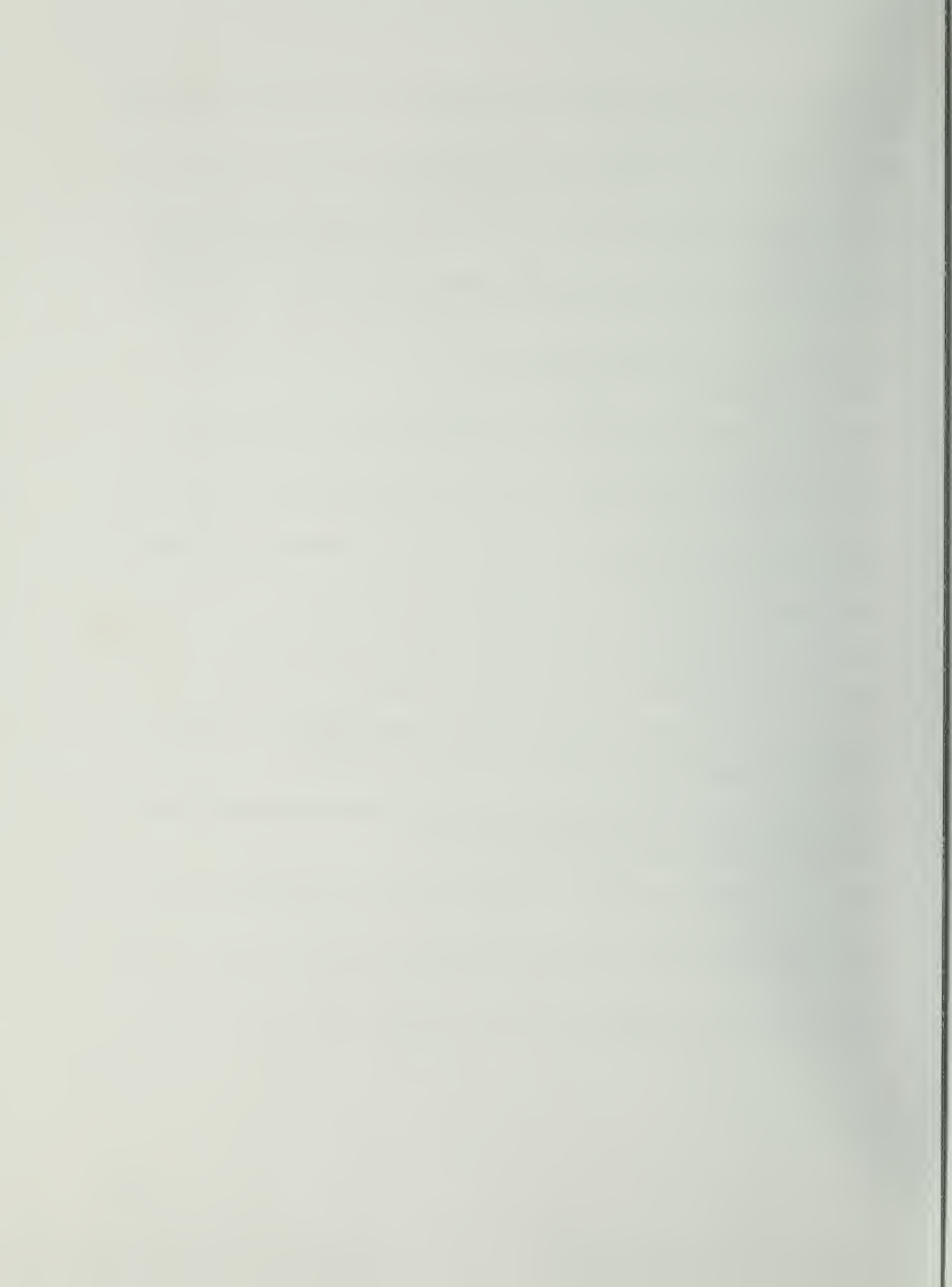
S&P manages a staff of 82 full-time equivalents with a budget of \$4.4 million.

The information S&P produces is used federally, provincially, and abroad by

- scientists, managers, and technologists doing agricultural research
- agricultural extension professionals
- politicians responsible for science policy
- educators and students studying agriculture and the environment
- farmers, producers, and processors in the agri-food industry.

Agriculture and Agri-Food Canada Publications

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Mandate

The St. John's Research Centre conducts research for crop production on mineral and peat soils under cool climate conditions. It develops techniques for

- improving forage production
- producing vegetables on peat lands
- managing stands of native fruit
- controlling soil-borne potato pests of quarantine importance.

Achievements

- *Staff awards and honors*
- *Lingonberry cultivars*
- *Controlled-release fertilizer*
- *Paper mulch*
- *Potato and vegetable diseases*
- *Land drainage*
- *Integrated pest management*
- *Forage seeders*
- *Grain industry*
- *Orchard grass*
- *Wart-resistant potato*
- *Clubroot-resistant rutabaga*

Staff awards and honors Mr. K.G. Proudfoot received the 125th Anniversary of Confederation Commemorative Medal for contributions that benefited fellow citizens and community. Mr. K.G. Proudfoot was also inducted into the Atlantic Agricultural Hall of Fame, in recognition of his contribution to the agricultural industry in Atlantic Canada, particularly with respect to the potato breeding program at the St. John's Research Centre.

Lingonberry cultivars A joint Federal - Provincial project assessed three lingonberry cultivars imported from Germany for their adaptability to Newfoundland conditions. Results since 1992 showed that new plantings should be covered with straw or similar material for at least the first couple of years in areas where snow cover is unreliable, to reduce problems of frost heaving. Plant survival and growth has been good at the Pynn's Brook site. Production in grams per 6-m row at Pynn's Brook was as follows in 1995:

- Koralle - 931
- Red Pearl - 602
- Ammerland - 318.

Controlled-release fertilizer Plantacote 4M and 6M, two products from Germany with different nutrient-release times, were assessed on celery grown on peat soil. Yield data are not yet available, but based on visual ratings of plant size and color, Plantacote 4M appears more suitable for celery production than Plantacote 6M.

Paper mulch The effectiveness of five brands of paper mulch in controlling weeds in vegetable crops on peat soil was studied. None of these products, from Germany and Austria, are suitable for use by commercial growers in Newfoundland:

- Ola-Perfektmulch
- Flexipack
- Rudolf Schachtrupp Mulchpapier
- Rudolf Schachtrupp Auslegepapier
- N+F.

Potato and vegetable diseases Pathotype differentiation is being studied under a Matching Investment Initiatives contract, using polymerase chain reaction analysis and fatty acid analysis of resting spores of *Synchytrium endobioticum* (RSSE). Melanin, a fungal agent implicated in spore persistence, has been detected in RSSE wall. Growing potatoes in the presence of *S. endobioticum* has so far proved difficult. RSSE impacted on spore traps downwind from infested soils. RSSE removed from vehicles leaving the province show the dangers of not inspecting vehicles. Field experiments with brassicas in crab-shell-treated soil and clubroot are encouraging.

Land drainage A 3-year study of subsurface drainage performance in Newfoundland continues to show improved forage yields. Forage yield samples taken from drained and undrained sites, receiving similar fertility inputs, were consistently about 100% greater on drained sites. Mean NO₃-N concentrations in drainage water samples collected at three on-farm sites during the 1995 field season were less than 5 mg/L.

Integrated pest management Cabbage maggot egg traps can be used to monitor pest populations and indicate optimal treatment timing. A joint proposal (Canada - Newfoundland Green Plan) with the University of New Brunswick and the provincial Department of Fisheries, Food and Agriculture, to investigate managing lingonberry fruitworm using pheromones, was accepted.

Forage seeders Durability of several commercial minimum-tillage forage seeders was evaluated on Cochrane gravelly clay loam soils of the Avalon Peninsula, in cooperative trials with commercial dairy farmers. Farmers preferred a power-till seeder with superior seedling establishment characteristics, but found it prone to breakdowns. They rated two implements with disk openers as acceptable, because the machines showed good durability in spite of slightly poorer seedling establishment characteristics. A commercial slot aerator showed excellent durability after going through 200 acres of trials on rocky and gravelly soils.

Grain industry Field trials have demonstrated the excellent economic feasibility of a possible feed-grain industry in eastern Newfoundland. Barley and oat grain and straw yields would generate revenues in the \$1500 to \$3000/ha range, with cost of production at \$500 to \$550/ha plus capital costs of \$7500/ha for land clearing. Wheat yields would also bring approximately \$2000/ha revenue in a 1995 trial, but risk of crop loss for commercial farmers would be much greater because of the crop's requirement for a longer growing season. The provincial market demand of 50 000 tonnes of grain is largely in eastern Newfoundland.

Orchard grass Management methods for growing orchard grass on the dominant soils of the Avalon Peninsula were effective in 7 years of trials at the St. John's Research Centre. Variety selection plus adequate liming and fertility are the key factors needed to establish this versatile crop in eastern Newfoundland.

Wart-resistant potato Selection N1522-8 has been registered as AC Blue Pride and is filling the local niche market for a long blue variety with wart resistance. A wart-resistant red-skinned selection from a cross of Brigus and Redsen performed satisfactorily in preliminary trials. Stocks have been multiplied, and comparative on-farm trials are being conducted. The potato-breeding program continues to emphasize incorporating scab resistance into selections with colored skins that are resistant to wart and cyst nematodes.

Clubroot-resistant rutabaga Breeding material from New Zealand was used to incorporate further sources of clubroot resistance into rutabaga breeding lines with good commercial potential. Researchers are attempting to develop a clubroot-resistant variety that produces roots of commercial size earlier in the growing season. To do so, they have crossed the English variety Lizzy, which is susceptible to clubroot, with Kingston and other clubroot-resistant lines. Disease resistance and storage characteristics are being evaluated.

Resources

The centre has a staff of 26 full-time equivalents, including six research scientists, and a total budget of \$1.7 million. Facilities include offices, laboratories, greenhouses, and numerous farm buildings, located on 64 ha of land near St. John's. Land at the St. John's site is used primarily for forage, potato, and integrated pest management trials. Two field sites located 80 km and 67 km, respectively, from St. John's provide added field research capabilities. The peat soil of the 280-ha Colinet field site is used for vegetable production research, drainage experiments, and maintenance of disease-free potato breeding stocks. The 14-ha Avondale field site is used for blueberry trials, as well as for field evaluation of the resistance of potato stocks to wart disease and potato cyst nematode. The centre provides the Food Production and Inspection Branch with greenhouse space. Provincial agriculture offices and greenhouse research facilities of the Canadian Forest Service are also located at the centre.

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Mandate

The Charlottetown Research Centre has a mandate for conducting research on potato management and feed crops and serves as the national centre of excellence for sustainable potato production systems. It conducts research on

- cereal and forage crops
- management, protection, and nutrition of potatoes
- soil management and conservation.

Achievements

- *New cereal and forage cultivars*
- *Livestock feed crops*
- *Fusarium and alfalfa*
- *Integrated disease control*
- *Weed control in barley*
- *Herbicide registration*
- *Potato production*
- *Verticillium wilt*
- *Green manure crop*
- *Potato rotations*
- *Irrigation*
- *Liquid manure storage*
- *Metribuzin use*
- *European corn borer*
- *Cabbage looper*
- *Fertilizer*
- *Organic matter quality*
- *Attributes of soil organic matter*
- *Tillage strategies*
- *Soil physical quality*
- *Soil erosion*
- *Mulching rates*

New cereal and forage cultivars AC Gabriel is a feed wheat less infected by septoria leaf and glume blotch and by powdery mildew than are check cultivars. AC Walton is a milling wheat cultivar resistant to powdery mildew and moderately resistant to septoria leaf and glume blotch and to fusarium head blight.

AC Alma and AC Westek are six-row barley cultivars. AC Westek barley is resistant to powdery mildew and has improved response to net blotch.

AC Charlie and AC Kingston are two new red clover cultivars. AC Charlie has better yield and improved resistance to winter. The causal agent of red clover allelopathy in a red clover - corn rotation was identified as a biological - microbial agent.

Climax, the most commonly grown timothy cultivar in eastern Canada, outyielded 11 other recommended cultivars in tests. Four recently recommended cultivars, however, did show improvement over Climax in several traits, exhibiting

- a leafier crop in the first cut
- greater nitrogen, phosphorus, calcium, and magnesium concentrations
- faster regrowth
- less dead matter content in the crop.

Livestock feed crops Se added at 5 g/ha as Selcote ultra® raised the Se level in the first two cuts of forages. However, Se additions had to be increased to 10 g to raise the Se in barley above the minimum required level of 100 µg/kg. At the same rate of application, laboratory and commercially available selenate-Se sources were also equally effective in raising Se in barley grain. The Se content of soybeans could be increased sufficiently to supply all of the Se in rations formulated from 20% soybeans and other ingredients that have very low Se concentrations.

Fusarium and alfalfa *Fusarium* infection was evaluated in alfalfa stands varying in age from 1 to 9 years. *F. solani* was found to be the predominant *Fusarium* species associated with crown and root rot in alfalfa. The severity of crown and root rot correlated well with the incidence of *F. solani* but not with *F. avenaceum* nor *F. oxysporum*. *F. oxysporum* tended to be associated only with young stands. Predicted yields decreased with stand age and were correlated with both *F. solani* incidence and root rot severity.

Integrated disease control Integrated pest management of net blotch of barley with a foliar-applied fungicide (propiconazole) based on timing relative to disease development was studied. Timing the applications according to growth stage was as effective as timing them based on amount of disease present. Most important for producing a high yield was not disease control alone but planting in a timely manner.

Weed control in barley Response of 14 recommended barley cultivars to Refine-Extra applied for weed control was studied. Even though six of the cultivars had significant foliar injury soon after application, all recovered well and no yield reduction was noted. A half rate of the recommended surfactant was as effective as using the full rate.

Herbicide registration Collaboration among growers, the agri-chemical industry, and regional researchers resulted in registration of several herbicides and herbicide combinations under the Minor Use Program for weed control in sweet white lupins. They control

- annual broadleaf weeds
- annual grasses
- quackgrass.

Potato production A federal - provincial joint project determined the optimum nitrogen rate and in-row seed piece spacing for maximum yield for recently released varieties. The study indicates that potato producers in Prince Edward Island, when deciding on nitrogen rates and seed piece spacing, should consider

- costs
- potential returns
- variety grown.

Verticillium wilt Recent findings with researchers from The Netherlands have revealed unique aspects of the growth of the fungus *Verticillium* wilt of potatoes. Associated studies at Charlottetown elucidated the impact of these results on disease epidemiology and management. In addition, biotechnology investigations on more accurate and rapid pathogen detection methods have successfully resulted in new DNA assays.

Green manure crop Lupin was evaluated as a green manure crop the year preceding potato production over 3 years. The time of fall incorporation of a legume can have a significant effect on the N response of a succeeding crop. Early fall incorporation can result in significant fall N mineralization and winter leaching.

Potato rotations Cover crop research in potato rotations indicated that fall rye and oilseed radish were effective in reducing leaching of nitrate from soils following potato harvest. In other studies, delaying application of glyphosate to red clover reduced fall mineralization and leaching of nitrate in a barley - clover - potato rotation.

Irrigation Low seasonal rainfall in Prince Edward Island allowed positive responses in an irrigation study on potato. In 1994, the greatest response per year, irrigation increased the total yield of Russet Burbank potatoes from 28.6 t/ha to 44.9 t/ha, and Kennebecs from 34.8 t/ha to 57.6 t/ha. Irrigation also increased yields of the larger size tubers desired in the marketplace.

Liquid manure storage A sampling of storage facilities for liquid hog manure in Prince Edward Island highlighted significant differences among farms. Sampling at mid-depth provided a representative reading of nutrient concentrations. Manure side banding in potato showed that liquid hog manure could be successfully injected between the rows by modifying the tanker to achieve correct wheel spacing. Injected manure did not affect potato crop yield or quality when compared with plots receiving base fertilizer treatments. Injection of liquid hog manure below the soil surface significantly reduced ammonia losses, compared with surface-applied manure between the potato rows.

Metribuzin use The response of newly released potato cultivars to metribuzin herbicide was assessed. The results suggest that metribuzin can safely be applied pre- and post-emergence to Belmont. Pre- and post-application of metribuzin reduced both Canada #1 and total yields of Russet Norkotah in 1990. Total yields of AC Novachip were reduced in some years with metribuzin applied post-emergence.

European corn borer Efficacy of different monitoring devices was studied in potatoes over a 2 years. Compared with the blacklight trap, the water-pan trap caught more male European corn borers in both 1990 and 1991. The *Heliothis*-cone and delta-wing traps and the sweep-net samples were ineffective for males. The water-pan trap is an effective tool to monitor adult males in potatoes on Prince Edward Island. Results using this trap in 1992 suggest that the Iowa strain of European corn borer predominates in the population in Prince Edward Island.

Cabbage looper A binomial model for insecticide application was developed from counts of cabbage looper equivalents on cabbage grown in Prince Edward Island from 1988 to 1991. A threshold of 40% of plants infested with at least one larva of any of three species of *Lepidoptera* attacking the crop coincided 94.7% of the time with a threshold of 0.25 cabbage looper equivalents per plant. Comparison of both thresholds resulted in similar mean numbers of applications of insecticides and yields. However, plots managed at the threshold of 40% of plants infested required 42% less time to sample.

Fertilizer Pre-plant nitrogen fertilizer had no effect on germination, yield, or quality of the fresh-pack carrot cultivar Fancy Pak, grown from either raw or coated seed.

Organic matter quality The quality of organic matter in soil under cool-season perennial grasses was assessed, and changes in soil structure were determined. Soil bulk density, pore-size distribution, and shear strength were within the optimum range for a Charlottetown fine sandy loam. Soil structural stability differed among grass species. These differences, associated with greater levels of macroaggregates, were not related to differences in plant parameters, organic matter, or organic matter fractions. Organic matter parameters, commonly used to characterize soil stability in cropping systems, are less useful for soils under perennial grass with stable microaggregate structures.

Attributes of soil organic matter In collaboration with research centres in Ottawa and Sainte-Foy, useful attributes of soil organic matter quality were identified as follows:

- total soil organic carbon and nitrogen
- light fraction and macroorganic (particulate) matter
- mineralizable carbon and nitrogen
- microbial biomass
- soil carbohydrates
- enzymes.

These attributes are involved in various soil processes, such as nutrient storage, biological activity, or soil structure, and were used to establish different minimum data sets for the evaluation of soil organic matter quality.

Tillage strategies Conservation tillage strategies were assessed for humid temperate regions, especially those with a cool season subject to excess precipitation and high levels of crop residue. Major attributes of conservation tillage in humid climates would be

- the continuum of live soil cover, especially in the noncrop period
- use of mulches and residue incorporation
- speed and efficiency of crop establishment.

These attributes can be achieved through

- minimum tillage
- rotational tillage
- attention to tillage timing.

Soil physical quality The spatial and random variability of indices of soil physical quality in a humid soil moisture regime were studied in reduced tillage rotations. Classical statistics indicated variation was low for bulk density and water-filled pore space, and medium for macropore volume. Spatial variation determined using variograms indicated some degree of spatial structure for these indices. As well, the method allowed improved estimation of soil sampling size and spacing.

Soil erosion A versatile splash cup system was developed for soil erosion studies. The system comprises a plexiglass splash cup in a conical sheet-metal housing. The splash cup was successfully tested in two potato production systems:

- under mulching
- under different crop covers.

A 5-cm cup showed the greatest sensitivity to treatment variations in both splash dry mass and dry mass per unit area.

Mulching rates The effects of applying straw as mulch at rates from 2 to 8 t/ha on slopes from 5 to 9% was studied on runoff and erosion. Mulching at the traditional rate of about 4 t/ha of straw significantly reduced cool-season erosion. These tests confirmed there is no advantage in applying straw at higher rates.

Resources

The research centre operates with a total budget of \$6.3 million and houses under one roof approximately 89 full-time staff, including 20 scientific staff, as well as the staff of the Agriculture Division of the P.E.I. Department of Agriculture, Fisheries and Forestry. Also located at the centre is the P.E.I. district office of the Agricultural Inspection Directorate of Agriculture and Agri-Food Canada's Food Production and Inspection Branch.

The research centre operates two other properties: Upton Farm, where the forage and beef research programs are located; and Harrington Farm, which accommodates about 70% of the centre's field studies in cereals, potatoes, and soil tillage and conservation. The three locations have a total land base of 383 ha.

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Mandate

The Kentville Research Centre develops new cultivars and technologies for the production, adaptation, and protection of horticultural crops. In addition, it develops innovative technology for their storage, handling and processing. The centre also studies the nutrition and management of poultry.

Achievements

- *Strawberries resistant to red stele*
- *Postharvest ripening of strawberries*
- *Strawberry dormancy*
- *Raspberry hardiness*
- *Blueberry pollinators*
- *Blueberry fruit fly*
- *Wild lowbush blueberries*
- *Scab-resistant apples*
- *Spur-type apple tree*
- *Useful techniques in apple research*
- *Orchard integrated pest management (IPM)*
- *Fertility management of vegetable crops*
- *Modified atmosphere packaging*
- *Temperature control in stores*
- *Fruit-based products*
- *Heat-resistant molds*
- *Poultry feeds*
- *Co-location*

Strawberries resistant to red stele The strawberry cultivar Mira was introduced, offering

- very high yields
- good keeping qualities
- excellent disease resistance.

It is particularly useful as a late-season, red-stele-resistant cultivar. Genetic resistance is the principal long-term solution to red stele disease. Two wild strawberry species offer new sources of multi-race resistance, which is being transferred to more useful cultivars.

Postharvest ripening of strawberries Postharvest interactions between light and temperature elevated both the aroma volatiles and the color of berries harvested under ripe. Levels were equal to those of berries harvested at maturity. Understanding postharvest ripening could help to improve quality during transport and marketing of fresh strawberries.

Strawberry dormancy It is critical to accurately determine when strawberry nursery plants are dormant and ready for digging, storage, and transport. Changes in carbohydrate levels and respiration in association with onset of dormancy were studied. Several characteristics, including raffinose levels, show promise as dormancy indicators.

Raspberry hardiness Researchers have overcome a major constraint to expanding raspberry production in Atlantic Canada by identifying new, early and productive cultivars for New Brunswick. In addition, temperature and water availability were identified as key factors influencing growth and development of primocane-fruiting raspberries. New cultural practices have been recommended to adapt these findings.

Blueberry pollinators Restrictions on honey bee importation resulted in the evaluation of alfalfa leafcutter bees as lowbush blueberry pollinators. These bees could successfully pollinate this important crop. Recommendations for their use as managed blueberry pollinators were developed, and commercial pollination services using leafcutter bees have been started.

Blueberry fruit fly Captures of blueberry fruit fly adults on properly located traps provided an integrated pest management tool that could determine the need for and timing of control sprays, by region, within Nova Scotia and New Brunswick.

Wild lowbush blueberries Improvement in quality is vital to increasing market share for wild Canadian lowbush blueberries. In one study, variability among clones was characterized in terms of size, color, sugar, acid, and pigment content using multivariate analysis. Relationships between these attributes can be used by processors to assess quality, and in particular, to adapt it to color sorting of berries. In another study, quality of fresh berries could be extended to at least 4 weeks under 15% CO₂ and 1.5% O₂. Improving shelf life through controlled atmosphere storage enhances the potential of fresh fruit marketing.

Scab-resistant apples To develop a wider range of fruit types among scab-resistant varieties that would be adaptable to all Canadian apple-producing regions, crosses have now been made between selections from the Summerland and Kentville breeding programs.

Spur-type apple tree A 5-year study has characterized the growth of Hartenhoff, Stirling, and MacSpur spur-type McIntosh strains grown on five common rootstocks. This work will allow better recommendations regarding planting density and size control for these scion × rootstock combinations.

Useful techniques in apple research Electrical bioimpedance spectroscopy was successfully employed as a nondestructive method of analyzing multiple stress events. This technique is being used to study apple rootstock resistance to winter damage. Chlorophyll fluorescence spectroscopy was used to measure viability of apple tissue. This nondestructive technique could potentially diagnose a number of storage disorders. A photographic record of fruit characteristics of 48 fruiting apple rootstocks was also developed. This guide can help verify the genetic stability of rootstocks, a task that cannot always be done using vegetative characteristics.

Orchard integrated pest management (IPM) A sex pheromone lure and a slow-release apple-volatile lure were developed for monitoring eyespotted budmoth and apple maggot, respectively. Tebutenozide was shown to be IPM friendly. It controlled several lepidopterous apple pests well, with little effect on parasitic species. Furthermore, the predaceous mite *T. pyrii* has been thoroughly studied for its effectiveness as a biological control agent against leaf-feeding mites. Spray programs can now be modified to enhance its efficacy in biological control. Lastly, the incidence and role of wild apple and hawthorn as hosts for many orchard pests were assessed, and a control technique based on glyphosate injection was developed.

Fertility management of vegetable crops Zinc deficiencies in sweet corn on soils high in P could be corrected with foliar sprays of zinc applied at 1 kg/ha. This method was as effective as applying higher rates of zinc, banded at planting. Rates of P could also be substantially reduced in broccoli. There was no yield response in four out of five trials when soil tests indicated P levels of 525 - 700 kg/ha. A sap test to determine nitrate levels in processing tomatoes was developed that gave results equivalent to those obtained with time-consuming laboratory tests. The new test assesses a crop's N needs more rapidly than the traditional test.

Modified atmosphere packaging The objectional odor generated during modified atmosphere packaging (MAP) of cole crops was identified. It is caused by methanethiol, produced under low O₂ conditions. This finding allows development of better MAP packaging of some fresh vegetables.

Temperature control in stores A survey of produce temperatures in retail stores was followed by experiments to determine the cause and possible solution to poor temperature control in stores. To inform store employees how to handle produce and minimize temperature abuse, an animated video and a chart of recommended temperatures were prepared.

Fruit-based products Hurdle technology was applied to provide industry with a shelf-stable, low-acid, fruit-based product with acceptable safety, sensory, and processing characteristics. Microbial stability and safety was achieved by modifying product components. A novel method to describe the sensory quality of apple genotypes was developed. It was used to identify several new apple selections that have the potential to expand the supply of apples for the rapidly growing baked-products market.

Heat-resistant molds Frozen lowbush blueberries produced in the Maritimes and Maine were shown to carry significant levels of heat-resistant molds that can potentially cause problems for secondary processors. Blueberry field soils were shown to be the source of at least 12 heat-resistant mold types.

Poultry feeds The highest economic returns were obtained when *Cavena* (naked oats) was omitted from the starter feed for turkey broilers but was included at 65% of their grower and finisher feeds. Body weight gain of broiler chickens was influenced by basal grain source because of differences in feed conversions. Also, dietary lupin levels were shown to reduce growth.

Co-location A new memorandum of understanding will see the co-location of the incumbent poultry scientist post at the Nova Scotia Agricultural College in Truro.

Resources

The centre has 101 full-time equivalents including 27 scientists and a budget of \$7 million. It encompasses 188 ha on the eastern limits of Kentville and an additional 74 ha at its Sheffield Research Farm, 8 km north of the centre. The laboratory-office complex integrates the Research and the Food Production and Inspection branches of Agriculture and Agri-Food Canada, as well as the western regional staff of the Nova Scotia Department of Agriculture and Marketing. The centre also includes the Senator Hervé J. Michaud Research Farm, which encompasses an additional 28 ha of land near Bouctouche, New Brunswick.

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Mandate

The Fredericton Research Centre develops new cultivars and technologies for the production, handling, and management of potatoes. The centre also maintains a national repository of potato gene resources. In addition, the centre develops technologies for sustainable food production from dairy and beef cattle using regional land, forage, and animal resources. It also conducts research on

- soil management and conservation
- adaptation and management of tree fruits and berries.

Achievements

- *Potato trials*
- *Resistance to leafroll virus*
- *Nuclear stock industry*
- *Virus studies in potatoes*
- *Insecticides uses in potatoes*
- *Potato tuber dormancy*
- *Potato harvester*
- *Ruminant nutrition*
- *Forages*
- *Soil quality*
- *Drainage waters*
- *Stimulating growth in the apple nursery*

Potato trials Twenty-one advanced potato selections in regional trials included

- eight oblong - long entries with french fry potential
- seven entries with chip potential.

To respond to an increase in late blight, almost 50% of new seedling production is now from parents resistant to the disease. In long-term selection for resistance, 46 clones in an adapted Andigena population were produced with combined resistance to

- common scab
- late blight
- PVY
- wart.

Residual maximum likelihood (REML) analysis has been used successfully to identify superior entries in a large northeast US - Canada trial, and to identify resistant breeding lines in a multi-year late-blight trial.

Resistance to leafroll virus The cooperative breeding program in Ontario has produced

- a chipping selection with excellent chip color from cold storage
- a long russeted selection with excellent yield and quality.

The cultivars Snowden and Yukon Gold have been transformed with the potato leafroll virus coat protein gene. Resistance was established in a field trial.

Nuclear stock industry Exposing potato plantlets to a photoperiod pretreatment of 10 - 12 h in vitro increased yield of micro- and mini-tubers used for the nuclear stock industry. Rapid multiplication cultures showed growth reduction and greater variability when propagules were grown lacking leaves.

Virus studies in potatoes A method of nucleic acid extraction from tuber tissue was developed. Using this procedure and a nonradioactive cDNA probe, PVY was detected in freshly harvested, greenhouse-grown tubers of eight potato cultivars. The probe was specific to PVY, and the sensitivity of detection was up to 10 pg of viral RNA.

A reverse transcription and polymerase chain reaction (TR - PCR) system was developed for detection of PLRV from aphids. PLRV can be detected from a single viruliferous aphid or a single viruliferous aphid combined with up to 29 nonviruliferous aphids.

Insecticides uses in potatoes By replacing the traditional broadcasting of insecticides by their banding in the first half of the season, the volume used can be reduced. Costs to the grower can thus be lowered, as well as the risk of environmental contamination. This approach should encourage the use of bacterial sprays by decreasing the cost of applying these relatively expensive products.

Potato tuber dormancy A successful technology was developed to release potato tuber dormancy rapidly. The method uses the environmentally benign gases nitrogen, carbon dioxide, and oxygen. The technology should have potential where an environmentally friendly procedure is required for treating dormant seed tubers that are destined for disease testing or rapid multiplication.

Potato harvester A lightweight, high-speed potato harvester is being developed. Intellectual property is being protected and specific components are being transferred to the private sector. The aim is to meet the industry's need for

- reduced energy consumption
- lower manufacturing costs.

Ruminant nutrition Seal meal can replace traditional protein supplements at levels up to 2% of the total diet of lactating dairy cows, without altering milk components or yield.

Yeast culture supplements improve the efficiency of dietary energy use for milk production in the early postpartum lactation period.

Supplementing silage with protein research is resulting in marked improvements in calf performance and reproductive efficiency of the cow. This ongoing research with the beef cow will lead to improvements in cow - calf productivity through a better understanding of maternal nutritional requirements.

Forages Leaves and stems of early-maturing timothy cultivars had higher nutritive value at the same stage of development as later cultivars, but their proportions did not account for the differences in quality.

Legumes and grasses of different species and cultivars respond differently to partial and complete removal of UV_B from ambient radiation. The legumes are more adversely affected by UV_B than are the grasses.

Increasing the N additions from 0 to 200 kg/ha on swards of white clover, orchard grass, and meadow fescue grown in factorial combinations resulted in increased yield. N addition also affected the concentrations of minerals in the plants when the forages were actively growing, as follows:

- Ca decreased
- P and K increased
- soil nitrate and ammonium concentrations increased.

Soil quality Erosion losses from soil cropped to potatoes were four times greater when soils were hilled than when soils were unhilled. Soil loss was predicted by row - sideslope gradients. Coarse soil fragments decreased soil erosion, and this effect was described mathematically. These results can be included in soil-loss prediction models and will assist conservation planning.

Subsoil P was an important source of P to continuous corn, especially in soils with low levels of available P. Applying large amounts of fertilizer P led to suspected leaching of P in a coarse-textured soil.

An apparatus was built to place limestone into compacted subsoil during deep-ripping. Up to 40% of the soil volume was enriched with limestone. No redistribution occurred in the year following deep placement.

Drainage waters Atrazine concentrations in subsurface tile drainage waters were 0.1 - 29 $\mu\text{g/L}$ during 30 consecutive months. Concentrations were highest after application and declined to about 0.1 $\mu\text{g/L}$ the following spring.

Stimulating growth in the apple nursery Mixing artificial growth media in the root zone increased

- tree height
- trunk diameter
- laterals.

This technology may permit fruit production to commence in the first year after transplanting.

Resources

The centre has a total staff of 124.7 full-time equivalents including 28 scientists and manages a budget of \$8.1 million. The land base at three locations covers 885 ha. The centre operates a potato-breeding field site at Benton Ridge, about 100 km west of Fredericton, and a research farm at Nappan, N.S. The Nappan Research Farm shares its facilities with the regional extension offices of the Nova Scotia Department of Agriculture and Marketing and the Maritime Beef and Swine Test centers. The centre also shares its office - laboratory building with the Food Production and Inspection Branch of Agriculture and Agri-Food Canada and with head offices of the New Brunswick Department of Agriculture.

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Mandate

The Research and Development Centre at Sainte-Foy develops new cultivars of forage crops, primarily alfalfa and timothy, for eastern Canada. It also conducts research on

- soil and water conservation for Quebec
- forage and grain production
- wheat improvement.

In addition, the centre develops techniques for producing and using forages in central northern areas.

Achievements

- *Cropping practices and organic phosphorus*
- *Cement factory dust*
- *Potassium and alfalfa production*
- *Straw decomposition in soil*
- *Taxonomy of rhizobiums*
- *Nitrous oxide emission in soils*
- *New stands of alfalfa and timothy*
- *Transgenes and alfalfa*
- *Cold hardening of plants*
- *Cover crop*
- *Persistence of ryegrass*
- *Cereal crops and wheat midge*
- *New wheat line*
- *ACCA barley resistant to yellow dwarf*
- *Ergot in barley*

Cropping practices and organic phosphorus The following practices promote the active compartmentalization of organic phosphorus in the soil:

- crop rotations
- minimum tillage
- addition of organic matter.

The result is a lower retrogradation of phosphorus from fertilizers. The microbial biomass of the soil is central to this process.

Cement factory dust When cement factory dust was applied to potato and alfalfa crops, yields were equal to or even higher than those obtained when potassium chloride fertilizers were used. Barley yields, however, were not affected significantly by the use of cement factory dust. Cement factory dust had no significant impact on concentrations of metals measured in soils cropped during the 3 years of production.

Potassium and alfalfa production Potassium fertilization, at rates ranging from 0 to 400 kg/ha, produced significant increases in alfalfa yields in only two out of six crop years on Sainte-Foy and Levis loamy soils. In only one crop year did the application of potassium prove cost-efficient. The percentage of survival of alfalfa increased, though, with the levels of potassium fertilization.

Straw decomposition in soil The decomposition of crop residues in soil depends on plowing methods and the postharvest treatment of residues. Crushing wheat straw before it is plowed under speeded up the decomposition process. The reverse effect was observed for green rye residues. In this case size reduction slowed down decomposition while increasing the quantity of organic matter left in the soil.

Taxonomy of rhizobiums The 32 strains of rhizobium isolated from the legumes *Astragalus* and *Oxytropis* do not constitute a single species. Most of the strains are grouped under the genotypes related to

- *Rhizobium loti*
- *R. huaknii*
- *R. ciceri*.

Some are related to *Bradyrhizobium*. In the population, nine strains of Arctic origin, adapted to the cold, are grouped under four genotypes related to these species of *Rhizobium*. The characteristic of cold adaptation is therefore not connected to the phylogenetic position of the strains.

Nitrous oxide emission in soils In the agricultural ecosystem, a sharp increase in nitrous oxide flows is observed at the beginning of snowmelt. At this time, nitrogen levels of the snow load are at their highest, and the first fractions of meltwater are highly concentrated in solute. These significant flows of nitrous oxide could influence annual greenhouse-gas budgets. In the area of biological processes, low-temperature (2°C) denitrification activity is detected throughout all months of the year. This activity increases significantly at 7°C in the spring and fall, in response to seasonal agricultural and environmental factors. This observation indicates greater biological activity at snowmelt.

New stands of alfalfa and timothy A new experimental stand of alfalfa, SF9102, and three experimental stands of timothy, SF8703A, SF8903 and SF8904, have received approval from the *Conseil des productions végétales du Québec* for licensing. The alfalfa stand combines a forage yield 8% higher than the yields of control varieties and shows tolerance to

- bacterial wilt
- verticillium wilt
- phytophthora root rot.

The three stands of timothy offer excellent forage yield at spring cutting and a high aftermath.

Transgenes and alfalfa The promoter of ribulosebisphosphate carboxylase (Rubisco) was isolated from plants derived from the alfalfa cultivar Apica. The expression modulated by the Rubisco promoter is specific to the foliage. Results indicate that transcribed coding zones of the Rubisco gene confer stability on the mRNA of the transgenes.

Cold hardening of plants The hardiness characteristic of alfalfa cultivars is closely associated with the accumulation of the soluble sugars raffinose and stachyose. The close relationship between the expression of specific genes and the degree of hardiness of alfalfa cultivars was demonstrated.

Cover crop The average yields of various forage species declined by 22 - 66% at first cutting and 2 - 32% at second cutting in the 1st year of production, when they were seeded with a barley cover crop.

Persistence of raygrass The winter survival of raygrass is strongly influenced by crop management. The frost tolerance of raygrass is directly related to the abundance of fructans of high molecular weight. Nitrogen fertilization increased the free amino acid content of plants, which could promote the vigor of the spring aftermath.

Cereal crops and wheat midge The wheat midge was observed in wheat fields in all agricultural regions of Quebec in 1994 when wheat had reached the milky stage of ripening. Among the heads examined, the degree of contamination ranged from 36 to 82%, depending on the locality. The average number of larvae per head ranged from 1 to 5. The infestations were more severe in the regions with the highest temperatures. No correlation was found between the presence of the insect and the degree of contamination of grains by bacteria, fungi, and *Fusarium* spp. at this early grain ripening stage.

New wheat line A new line of spring wheat of intermediate quality, Q.W. 533.13, received support for regional licensing in Eastern Canada. This line is characterized by very high tolerance to head blight.

ACCA barley resistant to yellow dwarf Laval University obtained licensing of the new barley cultivar ACCA. It relied on the cereal pathology expertise of teams at the Sainte-Foy Research Centre in developing ACCA. ACCA is the first barley cultivar resistant to yellow dwarf to be licensed in Canada.

Ergot in barley The barley cultivars Laurier, Maskot, and Sabina showed the greatest resistance to ergot (*Claviceps purpurea*). In contrast, the barley cultivars Albany, Léger, Symko, and Morrison were very susceptible to the disease. High seeding rates reduced the sclerotium content.

Resources

The centre is close to Laval University, which houses one of the most important faculties of agriculture in the country. It has a staff of 90 full-time equivalents, including 29 scientists, and a total budget of \$6.6 million. The centre operates a 75-ha field site at Saint-David-de-l'Auberiviere, about 15 km south of Quebec, where work on plant production is done. The centre is also in charge of the 140-ha Normandin Research Farm northwest of Lac Saint-Jean.

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Mandate

The Dairy and Swine Research and Development Centre in Lennoxville improves the productivity and profitability of dairy and swine production for Canada. The centre also develops methods to improve sheep and beef cattle production for Eastern Canada.

Achievements

- *Folic acid supplement*
- *Animal behavior*
- *Metabolism of nitrogen and hormones*
- *Somatotropin*
- *Stray voltage*
- *Growth-hormone-releasing factor for lactating sows*
- *Folic acid and feed composition tables*
- *Simulation software*
- *Total phosphorus*
- *Liquid hog manure and water contamination*
- *Fertility of ewes*
- *Milk production and beet pulp*
- *Total production of fecal matter*
- *Bird's-foot trefoil*
- *Gestation rate*
- *Intake prediction equations*
- *Silage and weight gain*

Folic acid supplement Folic acid administered in supplements to dairy cows from the 45th day of pregnancy to the 6th week after calving increased milk production by 14%, and raised milk protein levels by 6% during the second half of lactation. In the first 6 weeks of lactation, milk protein levels rose by 9%, from 32.3 to 35.1 g/kg, as a result of the folic acid supplements.

Animal behavior Cows and calves learn quickly to distinguish between individuals who treat them well and those who do not. Animals avoid people who don't treat them well. Cattle quickly associate a place with painful treatment. Fear can be reduced in cattle by making sure that all painful treatments are administered in a special location and not in the animal's stall or milking parlor.

Metabolism of nitrogen and hormones When fish meal is added to grass silage as a feed for cattle, net ammonia release by the portal-drained viscera is increased. It is metabolized by the liver into urea and excreted in the urine. The arterial concentration of insulin increases because of a greater release of insulin into the portal vein. The glucagon concentration increases in the arteries because of reduced use by the liver. This work shows the importance of the gastrointestinal system in the metabolism of nitrogen and hormones.

Somatotropin In dairy cows, a low level of intake (70% ad libitum) does not influence the responses of somatotropin, IGF-I, and milk production following short-term administration of somatocrinin. The increase in concentrations of insulin and somatomedin I and 3 binding proteins, observed only in cows fed at libitum, seems to indicate an increase in the insulin resistance of peripheral tissues following an administration of somatocrinin.

Stray voltage A transient stray voltage of 8 V did not have any harmful effects on

- feed behavior
- rest and prolificacy of sows
- piglet growth and mortality.

Growth-hormone-releasing factor for lactating sows Injections of growth-hormone-releasing factor to lactating sows increased weight of suckling piglets on day 14 while decreasing feed intake of sows.

Folic acid and feed composition tables Folic acid concentrations listed in feed composition tables are unreliable because they are measured on the basis of inadequate sampling, using nonstandard methods. Furthermore, the bioavailability of folic acid in feeds cannot be measured by serum concentrations of folates after the meal.

Simulation software A new swine simulation software is being used

- to evaluate the effects of various feed and management strategies on feed consumption and on the growth and composition of feeder hog carcasses
- to calculate the nutritional requirements of swine based on their genotype and stage of growth
- to propose methods of developing diets that can minimize nitrogen wastes, which are a major source of pollution.

Total phosphorus An analysis revealed that concentrations of total phosphorus in fresh feces, on a dry matter basis, ranged from 6.7 g/kg for beef cattle to 29.1 g/kg for feeder hogs. The inorganic form, equivalent to mineral fertilizer ranged from 34.8% in broiler chickens to 63.2% in dairy cattle.

Liquid hog manure and water contamination Preseeding and postemergence application of liquid hog manure, in line with grain corn agronomic requirements, did not contaminate runoff and drainage water with nitrogen and phosphorus during the spring any more than the application of mineral fertilizer did.

Fertility of ewes Energy level and protein degradability had differing effects on ewe reproductive performance depending on the breed and season. Flushing treatment is unnecessary when the ewe exhibits good body condition. Reduced fertility in the off-season is not the result of decreased efficiency of synchronization treatment. Reduced amounts of concentrates allow ewes to achieve good performances, provided they are fed quality forage.

Milk production and beet pulp Ewes nursing either two or three lambs produce similar quantities of milk when they are fed beet pulp, but ewes nursing two lambs have higher milk production when they receive commercial feedstuffs.

Total production of fecal matter The gradual-release Cr_2O_3 bolus is a better marker than insoluble ash in acid to predict total feces production of sheep fed grass silage ad libitum.

Bird's-foot trefoil Bird's-foot trefoil harvested at 75% flowering contains 48.2% protein nitrogen, as compared with 39.8% for silage harvested at early flower. The cultivar Léo contains more protein nitrogen than the cultivar Empire (47.2% versus 40.8%).

Gestation rate After an injection of prostaglandins, beef females that had not expressed estrus for 7 days were synchronized more effectively than those that had not expressed estrus for only 4 days. A single insemination and a single hormone treatment allowed 93% of females to be inseminated in 12 days and resulted in a 68% rate of gestation.

Intake prediction equations When feed intake is evaluated by equations, it is overrated by 17 - 23 %. Up to 95% of the variation in intake is explained by concentrations of

- neutral detergent fiber
- protein nitrogen
- propionic acid
- dry matter.

Silage and weight gain Researchers evaluated the effect of wilting on round bale silage using the performance of nursing cows. Wilting and storage method did not have a significant effect on

- weight gain of calves
- silage ingestibility and digestibility.

Round bale silage requires wilting of at least 24 h, while chopped silage may be harvested after about 3 h of light wilting.

Resources

The research centre staffs 140 full-time equivalents, including 30.5 scientists, and has a total budget of \$8.4 million.

The centre manages

- 400 ha and 300 dairy cattle at Lennoxville
- 244 ha and 600 sheep at La Pocatière
- 370 ha and 250 beef cattle at Kapuskasing.

Research Publications

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Mandate

The Horticulture Research and Development Centre develops environmentally sustainable techniques and systems of production for

- fruits
- vegetables
- ornamentals.

Achievements

- *Staff awards and honors*
- *Nematodes and biological control in vegetables*
- *Nematodes and weeds*
- *Parasitoid insects*
- *Digital scanning and insects*
- *Onion thrips*
- *Evaluation technique*
- *Prediction model*
- *Rotations on nuick soil*
- *Esseutial oils - Burkina Faso*
- *Frost resistance*
- *Leaf spot in strawberries*
- *Mite resistance*
- *Woody ornamentals in Quebec*
- *Embryogenesis and mutagenesis*

Staff awards and honors Retired since October 1995, internationally renowned apple specialist Raymond Granger, Ph.D. (physiology), was decorated with the Commemorative Medal for the 125th Anniversary of the Confederation of Canada. He also received the Merit Award to underline his professional accomplishments within the federal government. In addition, Dr. Granger was awarded the Order of Agricultural Merit from the Order of Agrologists of Quebec for his continuing training and information work with Quebec apple growers.

His professional accomplishments include the development of

- dwarf apple trees in Quebec
- new methods of pruning and training trees in high-density orchards
- varieties of scab-resistant apples for commercial growers and home gardeners.

Nematodes and biological control in vegetables Carrots sprayed with entomopathogenic nematodes were used as a lure to infect overwintering adults of the carrot weevil. The egg-laying rate of weevils feeding on the nematodes dropped significantly. Applying *Steinernema carpocapsae* nematodes in transplanting water proved more effective than chlorpyrifos in controlling young larvae of the cabbage maggot.

Nematodes and weeds Of the 32 weeds studied in carrot crops, 18 provided excellent conditions for the survival of the root-knot nematode, *Meloidogyne hapla*. Because this nematode deforms carrots, its populations must be kept within acceptable limits through a good weed-control program.

Parasitoid insects A recent study on *Anaphes victus*, a primary parasitoid Hymenoptera, showed that this insect changes its behavior depending on the egg-laying sites it finds. When parasitized carrot weevil eggs are present, *A. victus* kills the first parasitoid before laying its egg. The progeny of these primary parasitoid females develops into a hyperparasitoid.

Digital scanning and insects Digital scanning facilitated the study of trichogramma behavior to determine

- their host egg preference
- contact time with these eggs.

The same system was adapted to the behavioral study of lady beetle larvae in their search for eggs of lepidopteran pests of cole crops.

Onion thrips In onions grown on organic soils, action levels were established at

- 0.9 thrip per leaf under drought conditions
- 2.2 thrips per leaf under fairly normal conditions of precipitation.

These levels take account of

- yield losses caused by the pest, which may vary depending on climatic conditions
- the cost of chemical treatment to prevent these losses.

Evaluation technique To better evaluate weeders, raygrass (a fibrous-rooted monocotyledon) and white mustard (a tap-rooted dicotyledon) were selected as indicator plants and seeded at a predetermined density in rows perpendicular to the crop rows. This technique permits evaluation on a comparable and objective basis, since observations are made at known densities and phenological stages. Growing plants in rows perpendicular to one another also makes it easier to see the effect of the weeder on and between the rows.

Prediction model A severe attack by the *Cercospora* fungus increases carrot losses at digging because infected foliage is more fragile. A mathematical model using meteorological data predicts the intensity of an infection based on the length of time the foliage is damp. The model is used to determine

- periods favorable for infection
- the need to carry out treatment against infection.

Rotations on muck soil The introduction of a barley crop in rotation with carrots (barley - carrot - carrot) improved the saturated hydraulic conductivity and water-holding capacity in the grain crop year. On muck soils, nitrogen fertilization recommendations have to be reevaluated, as follows:

- to take account of the high rate of nitrogen mineralization
- to reduce contamination of ground water by nitrates.

Essential oils - Burkina Faso *Hyptis* and *Ocimum* species of the Lamiaceae family are used to control insect pests in grain storages in Burkina Faso. An analysis of the chemical composition of these plants found that *Ocimum basilicum*, which has a strong mint fragrance, produces the highest yields of essential oils.

Frost resistance The floral buds of apples protect themselves from winter frost by varying their charged and hydrophilic amino acid content at the end of the growing season. The accumulation of these amino acids and other hydrophilic substances, including certain glucides, lowers the freezing point of cell sap and living cells.

Leaf spot in strawberries This disease of strawberry leaves caused by the fungus *Mycosphaerella fragariae* causes

- leaf spot
- blackening of the sepals and fruit stem
- reduced plant vigor.

Development of the disease and sporulation of the fungus are related to the cultivar's susceptibility and temperature (around 18°C).

Mite resistance Strawberry resistance to two-spotted mites is an important factor in the breeding and selection of new cultivars. This resistance depends on the concentration in the foliage of

- sucrose
- alcohols
- phenolic products
- amino acids.

Woody ornamentals in Quebec *Rusticité et croissance des plantes ligneuses ornementales du Québec* covers the results of the woody ornamental testing network in Quebec. This 506-page work is designed for nurseries, providing information on the behavior of nearly 100 species, particularly in cold regions of the province.

Embryogenesis and mutagenesis This research on hybrid tea roses and hardy roses led to the identification of 50 new plants. Thirty contracts were signed for the propagation and sale of licensed hardy roses on international markets.

Resources

The centre manages 87 full-time equivalents including 26 scientists, with a total budget of \$6.1 million. The centre is also responsible for L'Assomption Research Farm (80 ha) and field sites at

- Lavaltrie (25 ha)
- Frelighsburg (134 ha)
- L'Acadie (86 ha)
- Sainte-Clotilde (32 ha).

Research Publications

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Agriculture and Agri-Food Canada Publications

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Mandate

The Food Research and Development Centre in Saint-Hyacinthe helps Canada's food industry become more competitive by conducting research in the area of food processing. The centre also promotes the development and transfer of new technologies, by providing a technological environment and making scientific and technical staff available to the food and beverage industry for the implementation of its research and development projects.

Achievements

- *Industry services*
- *Research and communications*
- *Francophone program*
- *Electric stimulation and quality of frankfurters in the meat industry*
- *Lactobacilli and sausage casings*
- *Cooking of ham in bags*
- *Microbial polysaccharides in bio-ingredients*
- *Fruit flavors*
- *Biostimulant yeast extracts*
- *Lactic whey starters*
- *Fermentation of yeast extracts*
- *Vanilla extracts*
- *Natural food color*
- *Storage technologies: fermentation and bread quality*
- *Storage of tropical products*
- *New agar-based ingredients*
- *Control of juice acidification*
- *Manufacture of protein isolates*
- *Continuous fluid sterilization*
- *Fruit dehydration*
- *Ozone in storing*
- *Cheddar cheese from microfiltered milk*
- *Multiphase ingredients adapted to light cheeses*
- *Coagulation of enriched milks*

Industry services One of the major attractions of the Food Research and Development Centre is that it allows the industries themselves to carry out research in pilot plants. A total of 76 confidential industrial projects, involving 76 companies, were carried out in 1994. This arrangement allows

- a high level of confidentiality
- rapid technology transfer into production.

Research and communications The centre has refined its approach to industry communications by examining the protection and management of intellectual property. The centre's agreements and information documents were reviewed. As a result, the centre

- suspended the publication of *Alimentech*
- maintained the distribution of *Profils technologiques* and *Techno*.

In collaboration with other organizations, the centre publishes

- *Publitech*
- *Trans-Faire*, the newsletter of the *Fondation des gouverneurs*
- *Agrosphère*, the newsletter of the *Technopole agroalimentaire de Saint-Hyacinthe*.

The centre joined with the *Fondation des gouverneurs* to produce a book on pathogenic microorganisms in foods, which we co-published with a professional publisher. The centre also allocated resources for the transfer of knowledge to the industrial sector.

Francophone program The objective of the program is the integrated development of small and medium-sized agri-food industries in Francophone countries. In 1995 two new partners joined the program:

- Haiti
- Romania.

The food color project was continued this year in collaboration with the Polytechnic University in Ho Chi Minh City, Vietnam, and the hibiscus juice project was concluded with the Food Technology Institute in Dakar, Senegal. A proposal for program renewal was submitted for 1996 - 1997, in which the *Association pour l'avancement des technologies en transformation des aliments (AFATTA)* has an important role to play.

Electric stimulation and quality of frankfurters in the meat industry The electric stimulation of carcasses at slaughter is now a common practice in the industry. The effects on meat quality are fairly well known. Very few studies have been carried out, though, on the effects of electric stimulation on the functional properties of meat. Our results showed that this technology, regardless of the voltage used, has little effect on the yields and quality of frankfurters.

Lactobacilli and sausage casings The adhesion of lactobacilli cells to collagen-based sausage casings is not affected by the presence of salt, sugar, or fatty acids in the surrounding environment. Adhesion is considerably reduced, though, in the presence of proteins. The effect is due mainly to a lower level of hydrophobicity in casings as a result of the adsorption of proteins on the surface. Treating the casing at processing could therefore reduce the risk of sausage recontamination in packaging rooms.

Cooking of ham in bags Under processing conditions commonly found in industry, the cooking cycle does not influence the degree of adherence of cooked ham to its bag. The extraction of myofibrillar proteins at tumbling is considerably less important in the adherence phenomenon than had been reported. Film-product adherence is strongly influenced by

- the composition of ham
- its degree of comminution.

Microbial polysaccharide in bio-ingredients Scaled-up production of a microbial polysaccharide on below-grade maple sap and syrup was carried out in bioreactors of 3 - 7 L. A study of the functional properties of this polysaccharide indicates that it could be used to stabilize low-viscosity emulsions.

Fruit flavors Yields of at least 10 g/L are obtained when ethyl valerate is produced by biocatalysis. Research is currently focussing on processes for collecting biogenerated esters.

Biostimulant yeast extracts Yeast extracts are frequently added to culture media because of the growth stimulants they contain. A large variation was observed, though, in their effectiveness. In collaboration with Lallemand Inc., a method has been developed to evaluate the biostimulant activity of yeast extracts. The bioscreen system, a programmable plate reader, allows the growth of lactic starters to be monitored simultaneously in 100 samples.

Lactic whey starters The growth media for lactic starters under external pH control contain variable quantities of whey. Protein concentrates of whey were therefore evaluated for this purpose. Basically the behavior of mesophilic cultures (*Lactobacillus lactis* ssp. *cremoris*) and thermophilic cultures (yogurt cultures) was similar on whey and whey protein concentrates. In both cases, the medium had to be supplemented with peptones and amino acids to obtain better growth.

Fermentation of yeast extracts Concentrated solutions of yeast extracts were used as a substrate for the production of diacetyl. In solutions of 10% solids, little growth was observed for

- lactococci
- lactobacilli
- pediococci.

Acceptable growth was observed, though, in extracts containing 7% solids. Production as high as 30 ppm of diacetyl was noted.

Vanilla extracts An analytical method was developed for measuring the main component of extracts of

- vanilla
- vanillin
- glucovanillin, vanillin's precursor.

This method will be used to develop a process for biogenerating vanillin.

Natural food color Crocin, a hydrosoluble carotene, can be produced by enzymatic glycosylation of crocetin, catalyzed by enzymes from saffron calluses. This reaction is inhibited by the polar solvents used to solubilize crocetin. This problem was resolved by encapsulating crocetin in maltosyl-beta-cyclodextrin.

Storage technologies: fermentation and bread quality The capacity of strains of *Pediococcus* to improve some bread quality characteristics was shown in three types of panary fermentation. The flavor of the corresponding bread was enhanced to varying degrees by

- the amount of pediococci
- the period of fermentation.

Inoculation of bread dough with *P. acidilactici* is an effective way of improving the flavor of breads, which otherwise would taste bland as a result of the fast process used.

Storage of tropical products A chitosan-based coating formulation that increases the storage life of mangoes by 20 - 30% at room temperature was developed. The storage life of tomatoes was also increased by using an appropriate chitosan-based coating. The ingredients used and the proportion of each in the formulation are keys to the successful application of the coating.

New agar-based ingredients New agar-based ingredients developed in collaboration with a Moroccan company

- lower the solubilization temperature
- allow their incorporation into food formulations not requiring any heat.

These ingredients become soluble in food formulations at temperatures ranging from 30 to 80°C.

Control of juice acidification Collaborative work with a company showed that the acidity of fruit juices can be controlled ecologically and economically with electrodialysis. This technology is an alternative to using ion-exchange columns.

Manufacture of protein isolates A process for manufacturing plant proteins by electrodialysis was developed. This technology is cleaner and more efficient than the traditional process of isoelectric precipitation with chemicals, because it uses only electricity.

Continuous fluid sterilization A technique for sterilizing fluids containing particles has been developed in a pilot plant, in collaboration with McGill University. Continuous dynamic sterilization of fluids with particles was found to be much faster than static system sterilization.

Fruit dehydration An apparatus has been developed that allows continuous contact of solid food particles with a concentrated solution to induce osmotic dehydration. The apparatus was tested for drying certain fruits in collaboration with two Canadian industries and a Moroccan company. The operating parameters for each category of fruit have been developed. Several commercial applications are possible. The soaking apparatus may also be used for the rehydration of horticultural products.

Ozone in storing The effect of various levels of ozone on the storing of fruits and vegetables was studied. This work made it possible to measure the impact of this technology on the microbial profile of the stored products.

Cheddar cheese from microfiltered milk Milk microfiltration was used to reduce the total flora in skim milk by 99%. The process, also called cold pasteurization, significantly reduced the number of psychrotrophic and sporulated bacteria with more than 99% efficiency. Milk purified by microfiltration was recombined with pasteurized cream for the manufacture of cheddar cheese. Cheese made from microfiltered milk contained fewer sporulated bacteria than the other two. Cheese produced from pasteurized milk had lower levels of lactobacilli and lactococci than cheese produced from heat-treated or microfiltered milk.

Multiphase ingredients adapted to light cheeses A multiphase ingredient consisting of a fine dispersion of butter oil integrated with a protein gel was developed as a fat substitute in light-type cheeses. A significant improvement in texture associated with the use of this ingredient was noted. A light cheese with 72% less fat had a texture comparable to that of regular cheddar made with whole milk.

Coagulation of enriched milks Densitometry was used to monitor the coagulation of milks enriched with

- ultrafiltration retentate
- microfiltration retentate
- acidified microfiltration retentate.

The coagulating properties of these enriched milks are different from those of regular milk. The coagulating properties of milk increase with the protein concentration, particularly in milks enriched with regular microfiltration retentate. Demineralization of the microfiltration retentate produces coagulating properties similar to those of an ultrafiltration retentate.

Resources

The centre uses a wide range of specialized, modern instruments to carry out research and has pilot plants with equipment specially designed for developing new products. The centre shares its premises with some 20 employees of the Food Technologies Service of the Quebec Department of Agriculture, Fisheries and Food and a technical adviser of the National Research Council of Canada. The centre has 76 full-time equivalents and employs 31 scientific staff. Its budget totals approximately \$7.4 million.

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Mandate

The Pest Management Research Centre at London

- develops alternative and environmentally acceptable technologies for the protection of tree fruits, vegetables, and field and ornamental crops from disease and insect pests
- develops alternative crops and sustainable management practices for coarse-textured soils
- preserves clonal germplasm
- determines the impacts of agricultural practices on soil and water quality.

Achievements

- *Rye cover crop*
- *Tillage practices*
- *Porosity and soil fauna activity*
- *Pesticides in soil ecosystems*
- *Pest management techniques*
- *Organic products against pests*
- *Mycorrhizosphere microorganisms*
- *Polymerase chain reaction based methods*
- *Verticillium dahliae*
- *Modified baculovirus*
- *Glutamate transport inhibitors*
- *Proteinase inhibitors*
- *Neem formulation*
- *Managing resistance*
- *Imidacloprid, a soil insecticide*
- *Integrated pest management and predators*
- *Degradative activity in soils*
- *Orchard insect pests*
- *Crown gall and grapevine rootstocks*
- *Apple scab disease*
- *Newly developed fungicide*
- *Resistant oriental fruit moth*
- *Avirulence genes*
- *Root-lesion nematode resistance*
- *Ginseng and soilborne pathogens*
- *Aut damages*
- *Stevia breeding program*
- *Fine-cured tobacco*
- *Western flower thrips*
- *Clonal genebank collection*

Rye cover crop Following a dry growing season, rye inter-seeded in corn reduced nitrate concentrations in the soil solution during fall and spring leaching to within the standard for drinking water. Following a wet growing season

- N leaching losses were lower
- growth of the rye cover crop was limited by competition for light and nitrogen
- the cover had little effect on nitrate movement to ground water.

Nitrate leaching was generally greater with conventional tillage than with no-till, indicating a more important role for the cover crop in conventionally tilled systems.

Tillage practices Crops differed in their response to tillage practices based on

- crop yield
- total phytomass production
- crop residue production
- crop residue soil cover.

The largest phytomass and crop residue production occurred with a continuous corn system; a soybean - wheat rotation produced higher phytomass and crop residue than a tobacco - rye rotation. The grain yield, total phytomass,

and crop residue produced by corn, winter rye, and winter wheat were no different between conventional moldboard plowing and no-tillage after 5 years of the study. In contrast, harvest yields, total phytomass, and total crop residue production were higher for soybeans and flue-cured tobacco under conventional tillage as compared with no-tillage.

Porosity and soil fauna activity Infiltrometer techniques to measure near-surface porosity in the field have been refined. The aim is to develop the use of soil-fauna activity as a bioindicator of soil porosity. Infiltrometer measurements provide a detailed insight into changes in pore size in soil resulting from a change from conventional to reduced or no-till practices. Linking of porosity measurements to the type and extent of faunal activity in soil should provide a means for a quantitative measure of changes in soil quality with time.

Pesticides in soil ecosystems Our results explain how levels of DDT are flowing into robin populations foraging in Canadian orchards. Earthworm species in Ontario have diluted DDT into the soil profile. But the Okanagan species are surface-dwelling only and continuously recycle DDT in the upper 5 cm of soil, where it breaks down very slowly. Robins feeding contaminated earthworms to nestlings provide a means for DDT to move up the food chain. Lead and arsenic, which were found at even higher levels in the same samples, use a similar pathway to flow into food chains.

This work is a proxy for nutrient transfer and pollutants in soil ecosystems. Researchers have devised a laboratory method for measuring the retention of pesticides in the walls of earthworm burrows. The method allows scientists to estimate the impact of no-till on herbicide levels in groundwater and surface run-off.

Pest management techniques No difference was observed in the total phospholipid content of soils used to grow five vegetable crops in rotation after 5 years under organic and conventional pest management techniques. Total lipid extracted, however, was consistently greater for soils on which organic pest management was used. Consistent, crop-independent differences were observed in the fatty acid composition of the phospholipids from the soils under the two types of pest management. The observation suggests that the significantly higher respiration rates observed for the organically treated soils were not due to an increase in the total number of microorganisms present. Rather, the work suggests that different soil microbial community structures develop with different pest management techniques.

Organic products against pests A spectrum of organic products, including animal by-products, soymeal, manures, paper sludges, and composts, were tested for their capacity to reduce verticillium wilt and potato scab. Tests were performed

- at farm locations
- in microplots containing soil from potato fields with a history of scab and wilt
- in microcosms under laboratory conditions.

Preliminary results indicate that

- organic amendments can control both weeds and a spectrum of diseases including scab, wilt, and nematodes
- disease reduction persists for at least 2 years
- yield benefits are more pronounced in the 2nd year after application
- laboratory tests predict the potential efficacy of a material under field conditions
- the efficacy of a product for reducing inoculum of pathogen is related to its nitrogen content
- manures and composts can increase or decrease pathogen populations.

Mycorrhizosphere microorganisms Filamentous bacteria capable of inhibiting the growth of pathogenic fungi and suppressing the development of several root diseases in tomato transplants have been isolated from the rhizospheres of field-grown tomatoes. The endomycorrhizal fungi *Glomus* and *Gigaspora*, which are in the roots of these field tomatoes, have been identified as additional growth promoters. The ecology and compatibility of these mycorrhizosphere microorganisms are being investigated under controlled environmental conditions.

Polymerase chain reaction based methods Primers were selected from a 1.5-kb portion of TPRI, the diagnostic DNA probe for bacterial speck of tomatoes. The compounds were used to develop a method for identifying this pathogen, based on the polymerase chain reaction (PCR). The 640-bp fragment amplified in the PCR reaction is unique to bacteria producing the phytotoxin coronatine. Lesions on fruit and leaves can be confirmed as being caused by bacterial speck in just a few hours.

A PCR-based assay is also being developed for bacterial spot, another tomato disease common to southwestern Ontario. The technique of genomic subtraction was used to isolate KK1750, a DNA fragment unique to the bacterial spot pathogen *Xanthomonas campestris* pv. *vesicatoria*. When tested against a wide range of tomato pathogens and saprophytes, KK1750 hybridized exclusively to the bacterial spot pathogen. The method is sensitive and rapid.

Verticillium dahliae The incidence of verticillium wilt was surveyed in 10 processing tomato fields in Essex County, in 1993 and 1994. On average, 30 - 40% of the plants sampled were infected with *V. dahliae*. Of 126 isolates tested for race type, 122 were identified as race 2. The prevalence of race 2 and the current lack of cultivars resistant to race 2 indicate the need for

- continued monitoring of the disease
- determination of the impact of race 2 *V. dahliae* on tomato production in Ontario.

Modified baculovirus A genetically modified baculovirus was released in small-scale field plots in 1994. It was extensively monitored for 1 year to determine its persistence in soil and foliage. Deleting the structural gene, p10, from the virus genome did not significantly reduce activity or persistence of the recombinant virus in the field, compared with the wild-type virus. In 1995, a second field release was conducted to monitor dispersal potential of the modified virus.

Glutamate transport inhibitors Proteins that transport amino acids across membranes are crucial components of the insect nervous system. But at present no insect control agents exploit these molecules as targets for pesticide action. Two *cis*-diastereomers of the L-glutamate analog L-2-(carboxycyclopropyl)glycine, which are actively accumulated by insect epidermis *in vitro*, have been identified from plant species in the *Ephedra* family.

These glutamate transport inhibitors may affect insect feeding. As the first step in the creation of a system that will allow the rapid screening of test compounds for effects on the activity of these molecules, the gene for a putative glutamate transporter protein has been cloned from the cabbage looper. The cloned gene is currently being modified for expression from a baculovirus vector in insect cell culture.

Proteinase inhibitors Progress has been made toward the identification of effective inhibitors of gut proteinases of the Colorado potato beetle (CPB). By emulating wounding using gaseous methyl jasmonate, a range of natural defence mechanisms, including proteinase inhibitors, have been induced in potatoes. CPB larvae reared on treated leaves have high levels of proteinases that are insensitive to the potato inhibitors. These proteinases can be used to screen for potential inhibitors from other natural sources.

Neem formulation Field trials demonstrated that applying extracts from the seeds of the Indian neem tree to cabbage leaves reduced populations of larval Lepidoptera. Effectiveness increased with the dose. Higher rates provided levels of control equivalent to that achieved with the registered pyrethroid cypermethrin. Similarly, trials with Colorado potato beetle also showed that a neem formulation provided a level of control equal to that of a B.t. product currently registered for use on tomato.

Managing resistance The relationship between farming practices involving pesticide use and the development of resistance is studied with the aim of prolonging the effectiveness of new products. Over three growing seasons, insecticide resistance in populations of Colorado potato beetle from a vegetable farm where crops were grown

organically increased to levels near those of beetle populations from a vegetable operation under an intense pesticide program. This observation reveals the role of immigration in promoting resistance and underlines the continuing difficulty in managing resistance.

Imidacloprid, a soil insecticide Continuing studies with the systemic soil insecticide imidacloprid under Ontario conditions indicated the following:

- control of Colorado potato beetle was greatly reduced when applied to muck soils
- foliar applications provided control for 8 days in the absence of heavy rainfall
- as a planting water treatment, 1.0 mg imidacloprid per plant provided excellent Colorado potato beetle control on tomato within 24 h of application and proved much superior to the commercial standard
- a seed dressing application controlled the first onion maggot population but did not control the second population.

Integrated pest management and predators Toxicity of insecticides to predatory third instar *Perillus bioculatus* nymphs was compared with that of Colorado potato beetle. Relative toxicities to the predator ranged from 67 times more toxic for endosulfan to 2.7 times more toxic for cypermethrin. In a similar test using *Podisus maculiventris*, cypermethrin was 3.6 times less toxic when compared with *P. bioculatus*. This combination of *P. maculiventris* and cypermethrin could prove to be a better choice for an integrated control program against Colorado potato beetle.

Rearing of *Stethorus punctillum*, a coccinellid mite predator, has progressed toward commercialization for greenhouse pepper and cucumber growers.

Degradative activity in soils Degradation of carbofuran and disulfoton sulfoxide/sulfone is stimulated in soils by the application of these pesticides. Degradation activity is still evident 3 years after the last application. Applying carbofuran to control cabbage maggot and onion maggot in 1995 was significantly less effective in soils where the pesticide had been applied the two previous years than it was in soil receiving its first application in 1995. These results suggest that carbofuran should be omitted in a pesticide rotation, to reduce the detrimental effect of a previous soil treatment on pesticide efficacy.

Enhanced degradative activity generated in soil to fonofos by a pesticide treatment in 1994 was still present in the spring of 1995. The efficacy of a 1995 application of fonofos for control of onion maggot was significantly reduced in the previously treated soil, compared with the soil receiving an initial 1995 application. The observation confirms the detrimental effect of previous fonofos treatment on the efficacy of subsequent treatments.

In a laboratory study, one culture selected from 179 disulfoton-degrading microorganisms caused total loss of the chemical in a soil over 28 days.

These results were obtained in loam, muck, and sand soils.

Orchard insect pests The codling moth and the apple maggot, both key insect pests of commercial apple in Ontario, can be controlled using significantly less insecticide than is currently recommended with no increase in other pest damage. They immigrate into orchards from nearby poorly managed or abandoned apple orchards, or from wild host trees. Current recommendations require the application of three to four sprays of insecticide to the entire orchard during the growing season. In a modified program, an initial spray of insecticide was applied to the entire orchard to eradicate any codling moths that had colonized the orchard during the previous growing season. Subsequent sprays were applied to a four-tree-wide zone along the perimeter of the orchard to prevent immigrant codling moths and apple maggots from entering the orchard. The effectiveness of the modified spray program is now being evaluated in all major Ontario apple production areas.

Crown gall and grapevine rootstocks A digoxigenin-labeled hybridization assay was developed for the detection of crown gall disease (*Agrobacterium vitis*), providing a highly sensitive, specific, and low-cost alternative to

polymerase chain reaction assays. A treatment of dormant grapewood substantially reduces levels of *A. vitis* and could provide a source of clean nursery stock to the industry. The field resistance of grapevine rootstocks to soilborne crown gall infection is being investigated.

Apple scab disease A new project on control of apple scab disease with biological strategies has been initiated. Hypovirulent isolates of *Venturia inaequalis* and microbes antagonistic toward *V. inaequalis* were identified. These isolates and microbes were evaluated as biocontrol agents of apple scab. With aerial applications, one of the four hypovirulent isolates tested significantly reduced severity of apple scab by 32 - 52%. All treatments with antagonistic microbes had 48 - 91% lower disease rate than the untreated check in greenhouse tests.

Newly developed fungicide Preliminary results of a project to commercialize the newly developed fungicide Azindoyl have been favorable. Evaluations of candidate formulations have indicated that Azindoyl is as effective as benomyl against sensitive isolates of *Botrytis cinerea*. It is also effective against benomyl-resistant isolates. Efficacy was influenced by the formulation ingredients.

Resistant oriental fruit moth Resistance to organophosphorus insecticides was confirmed in populations of Oriental fruit moth from the Niagara Peninsula. Laboratory assays showed a four times greater resistance to azinphosmethyl. Resistance to carbaryl and carbofuran is much higher. Cross resistance has also been identified to the phosphorodithioate insecticides phosmet, phosalone, and parathion but not to the phosphoramidates acephate and methamidophos nor to chlorpyrifos. Acephate and chlorpyrifos were extensively tested in field trials and by harvest were as effective as the standard pyrethroid program.

Avirulence genes Resistance genes in a host plant prevent disease only when the pathogen contains a corresponding avirulence gene. In a cross of *Phytophthora sojae* race 2 and race 7, avirulence to soybean resistance genes *Rps4* and *Rps6* is dominant and linked. Thus far, at least six of the soybean *Rps* genes appear to interact with corresponding single dominant avirulence (*Avr*) genes in *P. sojae*. Identification of pathogen avirulence genes will lead to development of diagnostic DNA probes for tracking pathogen populations and assessing the threat of new outbreaks. Avirulence genes also have excellent potential for application in engineering plants with new disease resistance specificities.

Root-lesion nematode resistance Evaluations of native sand-prairie grasses and forbs indicate that root-lesion nematode resistance may be widespread among these species. Six grasses and four forbs supported fewer than 200 lesion nematodes per kilogram of soil in a former tobacco field on sandy loam. The nematode-resistant grasses *Andropogon* and *Sorghastrum* show promise as alternative cover or rotation crops for nematode management in tobacco soils.

Ginseng and soilborne pathogens In laboratory assays, amendment of soil with composts reduced survival of soilborne pathogens of ginseng when compared with unamended soil. In fungicide trials, the application of pre-emergence fungicide delayed the establishment of *R. solani* damping-off within field plots but, once disease development began, the subsequent rate of expansion across the plot was similar to that seen in untreated plots. Post-emergence applications provided no disease control.

Biowaste substrates colonized by an isolate of *Trichoderma harzianum* provided biocontrol of *R. solani* damping-off of tobacco seedlings in growth chamber trials.

Ant damages Surveys were completed of populations of ants in 10 tobacco seedling greenhouses with histories of stand thinning by ants. Although the pavement ant appears to be the main problem species, other species such as the thief ant may well contribute to damage.

Stevia breeding program Five on-site industry researchers are working with Research Branch staff to optimize the sensory characteristics of stevia extracts through breeding. Other studies aimed at developing a production system are being conducted, and we are applying that information to pilot-scale on-farm production studies in southwestern Ontario. Substantial progress has been made in the breeding program, and 8.5 ha of stevia was produced by local grower cooperators.

Flue-cured tobacco Two new flue-cured tobacco varieties were registered in 1995:

- AC Gayed
- AC Joliette.

AC Joliette is a high-quality variety adapted to Quebec, and AC Gayed is a black root rot resistant, high-quality variety adapted to Ontario. Black root rot resistance provides the opportunity to eliminate the use of chloropicrin-enhanced fumigants, which will reduce costs by over \$2 million a year. AC Cheng, released in 1994, now accounts for 10% of the total tobacco crop at a value of \$25 - 30 million.

Western flower thrips Integrated pest management strategies for control of the western flower thrips in greenhouses are being developed from research in four major areas:

- thrips behavior and population dynamics
- thrips monitoring and timing of spray applications
- managing pesticide resistance
- developing biorational products as replacements for toxic pesticides.

Clonal genebank collection The clonal genebank collection comprises 2908 accessions. It includes

- *Fragaria* (strawberry)
- *Malus* (apple)
- *Prunus* (stonefruit)
- *Pyrus* (pear)
- *Ribes* (currant and gooseberry)
- *Rubus* (raspberry)
- *Rosa* (rose)
- *Sambucus* (elderberry)
- *Vaccinium* (blueberry).

Eighty-five requests for plant material, including 685 accessions and over 10 000 propagation units, were filled during the past year. Horticultural traits were evaluated in the field for

- 1500 native strawberry accessions
- 66 native raspberry accessions
- 58 named cultivars of currant and gooseberry.

To maintain plant health status, greenhouse virus indexing was completed for

- 300 *Malus* accessions, using three indicators
- 15 *Pyrus* accessions, using two indicators
- 37 *Fragaria* accessions, using three indicators.

Resources

The centre employs 159 full-time equivalent staff members, including 47 scientists. It has a combined land area of 236 ha and manages a budget of \$10.7 M.

Activities are conducted at four locations. The main centre is on 25 ha on Sandford Street in London and at the Siebens Drake Research Institute at the University of Western Ontario. It also includes

- Delhi Research Farm (60 ha)
- Vineland Research Farm, located on the Provincial Research Station property in the Niagara Peninsula, with a 30-ha field site located 3 km from the research farm
- Smithfield Research Farm (121 ha).

Research Publications

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Mandate

The Harrow Research Centre develops methods for improving the productivity of

- greenhouse vegetable crops
- field vegetable crops
- oilseed and protein seed crops
- soft white winter wheat
- grain corn
- tree fruits.

In addition, it develops new management practices for fine-textured soils.

Achievements

- *Honors and awards*
- *Rhizobia and drybean*
- *Resistant soybean cultivars*
- *White bean cultivar*
- *Corn breeding*
- *Detection of tissue-culture plantlets*
- *Transformed plants*
- *Harrow fertigation manager (HFM)*
- *Xanthomonas sp. strains*
- *Climate-control algorithms*
- *Greenhouse management system*
- *Western flower thrips*
- *Phytophthora sojae*
- *Soybean cyst nematode*
- *Blister spot*
- *Irrigation*
- *Weed management*
- *New studies*
- *Drainage sites*
- *Atrazine and runoff*
- *Grain corn and rotation*

Honors and awards Dr. A. Papadopoulos was elected president of the Canadian Society for Horticultural Science for 1995 - 1996. Dr. A.S. Hamill was selected as a fellow of the Weed Science Society of America.

Rhizobia and drybean In field studies, significant differences were observed among 17 drybean cultivars and 10 strains of rhizobia in

- plant growth
- yield
- nitrogen content.

Because there was no interaction between cultivars and strains, cultivars selected for high yield potential should be stable for a wide range of rhizobia.

Resistant soybean cultivars Field studies were conducted in cooperation with private industry to assist in the registration of two soybean cultivars:

- T9329 (Hyland Seeds)
- F1922 (First Line Seeds).

These cultivars by the Ontario Oil and Protein Seed Crop Committee are resistant to cyst nematode.

White bean cultivar AC Hensall was approved for registration by the Ontario Pulse Committee. The variety has resistance to

- all strains of bean common mosaic virus prevalent in Ontario
- alpha and delta races of anthracnose.

Corn breeding A corn inbred was developed, which will be useful in corn breeding. It is suited to three-way crosses, with yield approaching that of single crosses. It is being released to commercial breeders

- for hybrid production
- as germplasm for studies.

Detection of tissue-culture plantlets A computer software system for three-dimensional reconstruction of tissue culture plantlets was developed. The system detects potential plantlets and defines excision points. This capability is a prerequisite for automation of micropropagation of tissue-cultured plants. An industrial partner is being sought to develop the automated system.

Transformed plants In a collaborative study with Université de Montréal, tomato lines transformed with a chitinase gene from *L. ghilense* had a significantly lower foliar disease index than nontransformed plants, following inoculation with *Verticillium dahliae* race 1 or 2.

Harrow fertigation manager (HFM) This computerized multifertilizer injector was adapted to nutrient film technique (NFT). The system was evaluated under commercial conditions in 1994 and 1995. The HFM was shown to provide effective control of nutrient supply in NFT tomato culture. High commercial yield and fruit quality were achieved automatically and conveniently.

Xanthomonas sp. strains Some 21 strains of bacterial spot organism, *Xanthomonas campestris* pv. *vesicatoria*, were studied from southern Ontario. Only two were resistant to streptomycin, and none were resistant to copper. Seed treatments with Virkon (Vetoquinol) at 1% gave excellent control of both bacterial canker in tomato and bacterial spot in tomato and pepper without reducing seed germination.

Climate-control algorithms A computerized system for monitoring greenhouse environment was developed and used to characterize the microclimate of greenhouse crop canopies. Frequent episodes of leaf wetness conducive to fungal disease development were observed for a cucumber crop. These results indicate that many fungal disease problems in greenhouse crops can be reduced with use of improved climate-control algorithms.

Greenhouse management system A decision-support system for integrated management of greenhouse cucumber was developed and transferred to greenhouse growers for field evaluation. The system improves fruit yield and quality and reduces energy use by

- optimizing water and fertilizer application rates
- eliminating pesticide use through the recommendation of nonchemical control.

Western flower thrips In collaboration with Ohio Agricultural Research and Development Centre, a sampling program was developed for monitoring adult western flower thrips on greenhouse crops. A universal sampling program for thrips makes it easier for growers to monitor pest densities and optimize the timing of control measures.

Phytophthora sojae A survey of *Phytophthora sojae* isolates from Ontario revealed changes in virulence since 1989. New soybean varieties will require more than single genes for resistance.

Soybean cyst nematode Soybean growers were concerned about possible increased nematode populations when wheat crops are under seeded with clover. Greenhouse tests conducted with local red clover varieties indicated that clover does not support reproduction of soybean cyst nematode.

Blister spot A new symptom of blister spot on Mutsu apple was characterized and the causal agent, *Pseudomonas syringae* pv. *papulans*, was identified using Koch's postulates. The symptom is easily confused with fire blight (*Erwinia amylovora*) in the field. However, isolation of the causal agent by plating onto a selective medium allows for the correct disease diagnosis and appropriate management action.

Irrigation Both drip and sprinkler irrigation increased marketable yield of five tomato cultivars by an average 11 t/ha during a 4-year study in southern Ontario. In wet years, cultivar effects were greater than irrigation effects, whereas in dry years, irrigation treatments were of greater importance. A combination of a consistently high-yielding cultivar and a well-managed irrigation regime should improve yields under both extremes.

Weed management One cultivation combined with a reduced rate of metribuzin was shown to provide effective, economic weed control in soybeans. Cultivation or herbicide were unsatisfactory when used alone. Success of the management package was more pronounced in years of unfavorable growth conditions.

Studies in corn demonstrated that herbicide use can be dramatically reduced by

- banding over rows
- addition of ammonium sulfate to Roundup (Monsanto) and Touchdown (Zeneca)
- a single cultivation.

Seven chemical weed management programs were approved for tree fruits through the User Requested Minor Use Label Extension program of the Pest Management Regulatory Agency. Effective weed management combined with shorter residual activity reduces the threat of herbicide injury to crops grown following orchard removal.

New studies Undertaken this year, three new studies will evaluate

- a controlled drainage - subirrigation system on a farm scale
- 4 years of field data to show the potential impact on aquatic organisms of atrazine applied to corn
- the effects of fertilization and crop rotation on the sustainability of corn yields over 35 years.

Drainage sites Demonstration sites were established with

- the National Water Research Institute
- the Essex Region Conservation Authority
- three producers.

The sites will help determine the economic benefits and impact on the environment of the system. They will also raise farmers' acceptance of innovative technologies.

Atrazine and runoff The concentrations of atrazine in runoff were below those toxic to most aquatic organisms. However, this material could potentially have an adverse effect on phytoplankton diversity. Banded herbicide application to corn, with mechanical cultivation between rows, minimizes this indirect effect on biodiversity.

Grain corn and rotation Yields of corn grain

- increased by 29% with the fertilized rotation treatment
- remained relatively constant with the fertilized continuous corn
- decreased with the unfertilized treatments.

Precipitation during the growing season significantly influenced yield.

Resources

The centre employs 99 full-time equivalents including 26 scientists and manages a budget of \$6.7 million. Field operations occur at the main centre and Ridge field site, covering 131 and 21 ha, respectively, of representative sandy loam soils, and at the Hon. E.F. Whelan field site in Essex County, covering 67 ha of Brookston clay soil. Harrow also manages a research farm at Thunder Bay (123 ha). The centre shares office and laboratory space with extension specialists of Ontario's Ministry of Agriculture and Food and Rural Affairs.

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Mandate

Multidisciplinary teams at the Centre for Food and Animal Research (CFAR) carry out research focusing on commercializable and public-good technologies that are oriented to the client or customer. Key results areas include

- safety, quality, and added value of food and nonfood products
- biotechnologies that improve competitiveness of the animal industry and the food sector
- conservation of animal germplasm
- animal behavior - welfare and environmental management.

The cost reductions announced in the February 1995 federal budget will result in the closure of the centre over the 3-year time frame of the budget announcement. Priority programs are being transferred and consolidated at other centres of excellence across Canada.

Achievements

- *Microbiological safety of dairy products*
- *Controlling cheese yield*
- *Continuous production of tofu*
- *Utilization of okara*
- *Food microstructure*
- *Characterization of sensory properties of food quality assessment*
- *Evaluation of canola oil in infant formulas*
- *Salinomycin residues*
- *Microwave extraction technique*
- *Mycotoxins*
- *Rumen microbial ecology*
- *Bacteriocins and milk composition*
- *Rumen microbial protein production*
- *Rumen protozoa*
- *Ionophores and milk fatty acids*
- *Disease resistance*
- *Eggshell strength*
- *Lifetime profit in Holstein cows*
- *Farrowing crates for sows*
- *Pregnant sow welfare*
- *Cryopreservation of boar semen*
- *Conservation of animal genetic resources*
- *Embryonic stem cell culture*
- *Nuclear remodeling*
- *Tillage effect on chemical transport in tile effluents*
- *Anaerobic treatment of manure*

Microbiological safety of dairy products A mathematical model describing the thermal inactivation of *Listeria monocytogenes* in fluid milk was derived from experiments with a high-temperature, short-time pasteurizer. The model was incorporated into risk assessment software. Simulations were then performed to produce probability distributions. The output allows the user to assess the extent of risk associated with milk processing under specified conditions.

Controlling cheese yield Verification of a formula for predicting yield of cheese from composition of milk continues. The formula can now assess quantitatively the effect on yield of deviations in cheese composition. This technology is being tested by industry. A Canadian program for cheese analysis has been started to assist industry further in obtaining maximal yields.

Continuous production of tofu A continuous process for the production of ricotta cheese, developed by the Food and Feed Safety Group, has been modified to allow for the continuous production of tofu from soybean milk. Alliances have been formed with the food industry for technology commercialization.

Utilization of okara Significant correlations between physicochemical properties of soy proteins and tofu quality have been established among soybean varieties. These results may allow the development of a simple screening test for soybean breeders, thereby expanding the potential for export markets.

Food microstructure In a joint study with the California Polytechnic Institute, milk was coagulated at >85°C to pH 4.5 - 5.5, using acetic, lactic, and hydrochloric acids. The resulting curd was boiled and fried for varying periods of time. Electron microscopy has established useful relationships between microstructure and other properties of the treated curd.

Preliminary results on the microstructure of soy protein gels have been obtained. The plant origin of the gels is evident from the presence of cellular wall fragments. Differences in the microstructure of the gels was noticeable with some soybean cultivars.

Food microstructure studies have been initiated on kefir, a fermented milk product now being introduced to Canada. Unlike yogurt, kefir contains carbon dioxide and a very low (1%) concentration of ethanol. These components are products of the yeasts that are present in the starter culture, called kefir grains.

Research has shown a strong relationship between food microstructure and sensory attributes. With cornmeal, relationships were found between microstructure and human perception of particle size. With processed, instant oats there were structural manifestations of observed sensory properties.

Characterization of sensory properties of food quality assessment Swine and poultry diets in Eastern Canada have traditionally been based on barley and soybean. In collaborative studies with Kentville Research Centre, researchers examined sensory attributes of broiler chickens fed Cavena® in conjunction with barley and corn. No detrimental effects were seen in response to the addition of up to 25% naked oats in the starter diet and up to 60% naked oats in the finisher diet.

In Canada, oats is a nutritious grain that is under utilized as a food crop. Sensory panels successfully developed a profile to characterize two processed instant oats, developed from different cultivars of Cavena®. Processed instant oats could potentially replace rice. The profiles can now be used for testing future generations of oats.

Evaluation of sensory quality of meat was successfully supplemented with a technique called time intensity. Scientists using this method study texture breakdown over time, from the initial bite to swallowing. This additional information gives clearer illustrations of sample differences and allows more subtle variations in meat quality to be detected.

Evaluation of canola oil in infant formulas In previous research newborn piglets were fed milk replacer diets containing canola oil with 2% erucic acid. The normal rise in platelet counts from 300 to 600 × 10⁹/L was delayed by up to 3 weeks with this diet. The delay was attributed to the general fatty acid profile of canola oil and not to erucic acid *per se*, because an oil mixture that mimicked the fatty acid composition of canola, but which did not contain any canola oil, caused a similar delay in platelet counts. In addition, other oils such as olive oil and high oleic acid sunflower oil had similar effects.

To test if erucic acid *per se* would further exacerbate the effect on platelets of newborn piglets, a milk replacer was designed containing a rapeseed oil with 20% erucic acid. Preliminary results indicate that erucic acid at this level caused a 33% reduction in platelet counts after the 1st week. Counts remained low through the 4-week feeding trial.

Canola oil with much less than 2% erucic acid is recommended for use in milk replacer diets of the newborn, to avoid delaying the normal rise in platelet counts. Because milk replacers are generally prepared using fat - oil mixtures that mimic the fatty acid profile of maternal milk, and therefore contain only a small portion of any specific oil, the risk would be minimized even further.

Salinomycin residues To prevent coccidiosis in broiler chickens, the ionophore salinomycin is recommended as a feed additive. It is not approved for laying hens. In a collaborative study with the Food Production and Inspection Branch and Cairo University, Egypt, salinomycin residue profiles in eggs and tissues of laying hens were established. When salinomycin was fed to laying hens, maximum residues were deposited in the fatty components:

- subcutaneous fat
- ovarian yolk
- egg yolk.

Liver, kidney, and muscles had small but detectable residues.

Residues were dependent on salinomycin level in the feed and declined rapidly when the coccidiostat was withdrawn.

Microwave extraction technique The use of microwave energy has been investigated as an alternative to conventional sample preparation techniques for the analysis of drug residues in animal tissues and eggs. A novel microwave extraction technique has been developed and validated with incurred salinomycin in chicken rations, eggs, and tissues. The new method is

- simple
- cost-effective
- environmentally safe and reliable.

Mycotoxins A polyclonal antibody with high affinity and specificity against fumonisin B₁ (FB) was developed. Use of these antibodies in enzyme linked immunosorbant assay protocols improved the detection limits for FB in corn to 5 ng/g and in milk to 0.5 ng/mL. FB intake of as low as 0.1 ppm in swine could negatively impact on productivity.

Also with swine, feed refusal syndrome caused by deoxynivalenol appeared to be initiated at the peripheral level. A gastrointestinal response to the toxin interferes with normal behavior. Preliminary observations of the small intestine using electron microscopy showed structural changes caused by mycotoxin intake.

The effectiveness of various detoxification methods for fusarium-contaminated corn were evaluated. The easiest and most economical method on the farm was a quick rinse with water and removal of floating material. Research in collaboration with industry has shown that ensiling high moisture corn containing low levels of mycotoxins increases levels of mycotoxins during storage.

Rumen microbial ecology Scientists introducing novel strains of bacteria or genetically engineered bacteria into the rumen need sensitive systems to determine the success of the establishment of the bacteria and their effects. A comprehensive set of probes based on 16 S rRNA have been developed for the rumen bacterium *B. fibrisolvens*. The probes are based on sequences from over 60 isolates, as well as a competitive polymerase chain reaction method to detect the bacterium when it is present in very low numbers. The method has been used to determine

- the establishment of nonengineered strains of *B. fibrisolvens* in rumen fermenters
- the importance of this bacterium in the rumen of dairy cattle.

Bacteriocins and milk composition Researchers are developing new technologies that will allow producers to control milk composition. The methods are based on the use of bacteria-inhibiting proteins called bacteriocins. Two parallel surveys for candidate bacteriocins have been conducted

- to identify potentially useful bacteriocins, generally recognized as safe (GRAS)
- to identify and characterize native bacteriocins.

Bacteriocin production is a common feature among rumen bacteria of the genus *Butyrivibrio*. Many of the bacteriocins examined possess the range of activity against rumen bacteria needed to modify the rumen microbial population and thereby

- control milk composition, reducing milk fat levels and improving milk fat composition
- improve the efficiency of rumen fermentation.

Selected rumen bacteriocins are being isolated and characterized, and the genes for their production are being cloned.

Rumen microbial protein production The milk bundle protein (MB1) is a *de novo* protein enriched in the four amino acids that limit milk protein production. When produced at appropriate levels in rumen bacteria, MB1 should

- improve the quality of rumen microbial protein
- reduce ruminant requirements for dietary protein.

The gene encoding MB1 has been cloned in a rumen bacterial plasmid vector and introduced into rumen bacteria. Recombinant rumen bacteria carrying the MB1 gene have been shown to produce the new protein. Studies to further increase MB1 production stability within rumen bacteria are under way.

Rumen protozoa The natural population of protozoa destroys between 20 and 30% of protein in the rumen. However, protozoa maintain a higher ruminal pH and increase digestion of organic matter by 6 - 22%, which results in higher feed intake and growth. Experiments were done with individual protozoal species and their combinations. Only two species were required to maintain optimal pH and digestion parameters in the rumen of the host. With these two species, ruminal destruction of protein was decreased to 4%. Further research with re-entrant cannulated animals showed that progressive addition of other protozoa to this new population of the two protozoal species gradually increased the ruminal destruction of protein. It was estimated that the new population of ruminal protozoa could, on average,

- reduce the daily dietary protein supplement required for lactating cattle up to 2.4 kg of soybean meal a day
- decrease the ruminal production of methane by up to 25%.

Ionophores and milk fatty acids Long-chain fatty acids, C-16 and up, are transferred directly from the rumen to milk. A wide range of commercially available ionophores have been found to decrease biohydrogenation of fatty acids in the rumen and increase the levels of both mono- and polyunsaturated fatty acids. These changes are reflected in the fatty acid composition of milk by decreasing the concentration of 18:0 and increasing that of 18:1 and 18:2. These changes should improve the nutritional quality of milk and therefore appeal to the consumer.

Disease resistance Endogenous viral (*ev*) genes that reside permanently in the genetic makeup of the chicken are more frequent in meat-type than in egg-type chickens and can produce a virus similar to avian leucosis viruses. Eight semicongenic lines have been developed, each containing a single *ev* gene derived from meat-type chickens. Only one of these was the same as an *ev* gene found in egg-type birds. These semicongenic lines will facilitate the study of why meat-type birds have so many *ev* genes.

In response to Marek's disease virus (MDV), infected birds carrying various *ev* genes showed a marked increase in the CD4 plus T lymphocytes in the early stage of the infection, regardless of the presence of *ev* genes. Also, the number of cells expressing MHC class II antigen was severely reduced. These results showed that MDV infection modulates the development of immune reactions through its effect on lymphocytes.

The tyrosine kinase gene *hck* of the chicken is being characterized. This gene is similar to a human protooncogene. The insertion site of the endogenous provirus *ev3* is in intron 5 of the *hck* gene. However, the presence of the provirus *ev3* increases the expression of the *hck* gene by a factor of three to five, compared with birds free of the *ev3*. Since the equivalent gene to *hck* in humans influences macrophages and thus the immune system, the provirus *ev3* may exert an effect on the immune responsiveness of chickens through its effect on the *hck* gene.

Eggshell strength A new protein called ovocleidin 17 (OC17) has been isolated from eggshell matrix. OC17 accounts for less than 2% by weight of the eggshell but is believed to play a key role in controlling

- egg calcification
- eggshell strength.

In collaboration with three other research laboratories, research is in progress to elucidate

- the function of OC17
- the gene which controls its biosynthesis
- the distribution of OC17 in the shell matrix.

Lifetime profit in Holstein cows In a joint research study with the University of Guelph, the most accurate measure of lifetime profitability in Holstein cattle was found to be discounted lifetime profit adjusted for opportunity cost.

Many factors besides milk yield per lactation have an impact on lifetime profit. In order of importance these were

- average milk revenue per lactation
- length of productive life.

The highest negative impacts on profitability were made by

- more days dry
- later age at first calving
- more reproductive diseases.

The most important early indicator traits for lifetime profit were

- milk revenue in first lactation
- three-minute yield
- udder height.

Indicator traits with negative impact were

- later age at first calving
- more days from first insemination service to conception
- larger teat diameter.

Farrowing crates for sows Several hundred Ottawa farrowing crates, originally designed in the 1980s by the Animal Behavior Program, are now in commercial use on farms in eastern Canada. The crate allows the sow to turn around and go through normal postural changes, yet it provides a level of piglet protection comparable to very restrictive crate designs. In 1995 the Ottawa crate was installed for demonstration at the Lacombe Research Centre.

Pregnant sow welfare A new prototype system for housing pregnant sows has been designed and is now in experimental use. The system involves building a raised, group lounging area above existing sow stalls. Sows use their stalls at feeding time and at other times have voluntary access, via a short staircase, to the group area. The design gives sows freedom to move and socialize, while still allowing them to be fed individually.

Cryopreservation of boar semen To improve the efficiency of artificial insemination (AI), scientists assessed

- the effect of glycerol equilibration time
- the interaction between semen and final glycerol concentration.

Popular belief is that boar semen should be exposed to glycerol for the shortest possible time. However, longer equilibration times were found significantly more beneficial for sperm cryosurvival. Exposure times of 1 and 4 hours at 5°C produced the best-quality cryopreserved semen. The results represent an important step for cryopreservation protocols for local use and international marketing of boar semen for AI.

Conservation of animal genetic resources As a part of research to support the conservation of farm animal germplasm, data base inventories have been published and distributed across Canada for

- sheep
- goats
- swine
- laboratory animals.

These publications will help breeders form networks and to assess the rapidly eroding genetic base of individual domestic animal species. The technology of estimating the genetic distance between breeds also is being incorporated into the data base program, to make conservation efforts more efficient.

Embryonic stem cell culture Researchers are studying the development of embryonic stem cell lines. They have successfully established a bovine blastocyst culture system that allows the inner cell mass to be developed sufficiently to be harvested. The next stage is an efficient dispersal method for the inner cell mass to establish bovine embryonic stem cell culture. In addition, new sustainable media for mouse embryonic stem cells have been formulated, which give more efficient proliferation and thus better harvest.

Nuclear remodeling An extract from activated frog eggs induces

- complex cell cycle events
- DNA synthesis.

This extract is not species-specific, and similar action was evident in suspensions of bovine sperm. To show that DNA synthesis occurred, a technique adapted from tissue culture experimentation using fluorescence was adapted. The use of an activated frog egg extract would increase efficiency of in vitro fertilization of bovine oocytes and become a useful tool in the production of economically important transgenic animals.

Tillage effect on chemical transport in tile effluents In loam soil corn fields, effect of no tillage (NT) and conventional tillage (CT) was studied on long-term movement to tile drainage water of

- nitrate
- atrazine
- metolachlor.

Under both NT and CT, drinking water limits were exceeded most of the time for nitrate but not for herbicides. A treatment effect was not evident for concentrations of nitrate and metolachlor, but atrazine concentration was significantly higher for NT than CT. Loss of nitrogen as nitrate and herbicides over 40 months represented about 22% and less than 0.2% of the amounts applied, respectively.

Anaerobic treatment of manure A low-cost anaerobic bioreactor for animal waste has been developed. The new process has the following key features:

- it operates at low temperatures (10 - 20°C), which are typical of farm manure in Canada
- it does not require energy input to heat manure before feeding the digester.

Its benefits include the following:

- It effectively stabilizes, deodorizes, and increases the fertilizer value of swine manure slurry.
- Nitrogen is conserved and its mineralized fraction increases.
- Toxicities have not been shown to high concentrations of ammonia, volatile fatty acids, and antibiotics at mesophilic and thermophilic temperatures.
- The flow regime of the sequencing batch reactor is highly suitable for low-temperature anaerobic digestion because it provides optimum conditions for retaining the slow-growing anaerobic bacteria in the bioreactor.

The process is being tested on small and large farms, as well as with waste water from food-processing industries.

Resources

The Centre for Food and Animal Research is located on the Central Experimental Farm and has research facilities in seven buildings. The food program has specialized facilities for

- sensory and instrumental evaluation of food
- food microstructure research
- pilot-plant processing.

The facilities for animals and some supplementary laboratories are 14 km away at the 1100-ha Greenbelt Research Farm in Nepean.

The centre has a total of 281 full-time equivalents, of which 73 are in the professional categories, and operates with a budget of \$17 million.

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Mandate

The Eastern Cereal and Oilseed Research Centre (ECORC) develops new varieties and crop protection and management systems for the sustainable production in eastern Canada of

- corn
- cereals (wheat, barley, oats)
- soybeans.

As well, ECORC is responsible for land and biological resource evaluations and pest diagnostics for all of Canada.

Achievements

- *Awards and honors*
- *New tools to identify apple pests*
- *New information on soil-dwelling organisms*
- *Biocontrol advances*
- *Advances in insect identification*
- *Wild relatives and crop species*
- *Crop diversification*
- *Control of weeds*
- *Forage systematics*
- *Mycorrhizomes*
- *Contaminating molds*
- *A novel discovery*
- *Cellulose digestion in cattle*
- *Low-temperature rot of apples*
- *Plant Gene Resources of Canada (PGRC)*
- *Biocontrol research support*
- *Biological Resources Division Identification Service*
- *Product Development Unit (PDU)*
- *National standards for soil inventory*
- *Canadian Soil Information System*
- *National soil database*
- *Land resource data applications*
- *Soil-quality benchmark site network*
- *Analyses of soil and environmental quality*
- *Health of Our Soils: Toward Sustainable Agriculture in Canada*
- *LEACHM model application*
- *Biofilters*
- *Micrometeorological measurements to gauge farming practices*
- *Agrochemicals*
- *Soil quality evaluation program*
- *Soil organic matter*
- *New instrumentation*
- *Crop management aids*
- *More effective water management*
- *Soil conservation and crop productivity on the farm*
- *Photosynthesis efficiency*
- *Land use analysis and remote sensing*
- *Agro-environmental indicators*
- *Mycorrhizal soil fungi*
- *Wheat mycotoxin detection, quality, hardiness, and transformation*
- *Corn breeding, fusarium resistance, mycotoxins, and cold sensitivity*
- *Barley breeding, molecular markers, and diseases*
- *Oat industry collaboration and genome mapping*
- *Soybean breeding and transformation*
- *Forage, genetic engineering, hybrid alfalfa, and nitrogen fixation*

Staff awards and honors A prestigious award for career lifetime achievements, the Lawson Medal of the Canadian Botanical Association, was awarded to E. Small for his work on forage and diversification crops.

M. Schnitzer, now an honorary research associate with ECORC, shared the 1995 - 96 Wolf Prize in Agriculture with R. Stevenson of the University of Illinois. The Israel-based Wolf Foundation is dedicated to promoting science and art for the benefit of mankind. It recognized Drs. Schnitzer and Stevenson for their pioneering contributions to the chemistry of soil organic matter and applications in agriculture. Dr. Schnitzer worked for 35 years with the Central Experimental Farm before retiring in 1991. The prize is valued at \$100 000 US.

J.D. Miller was awarded the Science and Technology Award by the Ministry of Agriculture of the People's Republic of China. He was recognized for collaborative research on resistance mechanisms in fusarium head blight of wheat.

A team of land resource staff lead by S. Smith was honored with an award from the Canadian Council on Ecological Areas in the category "Government Department or Agency." The team worked collaboratively with Environment Canada to prepare the National Ecological Framework for Canada.

The Central Experimental Farm's Award for Team Excellence was presented to W.D. Reynolds, R. de Jong, S.R. Vieira, I.J. van Wesenbeeck, W. Greidanus, R.S. Clemente, W.N. Smith, and E. Topp. The award honored their development of methodology for predicting and characterizing nonpoint source agrochemical contamination of ground water on a watershed basis.

Certificates of achievement were presented by the Minister and Deputy Minister to R. Desjardins, D. Dow, G. St-Amour, and H. Hayhoe of the former Centre for Land and Biological Resources Research. The award recognized exceptional collaborative research and technology transfer during the first international satellite land surface climatology project experiment.

New tools to identify apple pests Adults of apple and cherry ermine moths can now be identified without host data. A molecular diagnostic test, developed in collaboration with the University of Ottawa, uses a genetic map of these species based on new genetic markers.

A taxonomic revision of all apple-feeding species of tentiform leafminers (*Phyllonorycter*) of North America was published. Leafminers infesting apple orchards in British Columbia can now be identified. This pest is the object of biological control research using parasites.

New information on soil-dwelling organisms Four important works were published, on the following organisms:

- the oribatid soil mite genus *Mycobates* of North America, including many new species
- oribatid mites of Canadian peatlands
- a weevil species new to Canada
- rove beetles of the subtribe Philonthina in North America.

Some results of this work include

- the possible use of the *Mycobates* mites as bioindicators
- the use of assemblages of *Limnozetes* species as bioindicators in characterizing peatlands
- preparation of a pest risk assessment on the new weevil species, a pest of ornamental cedars recently introduced into British Columbia
- a revised nomenclature for 208 species of rove beetles, which is in line with that used in Europe, the point of origin for many of the North American species. Rove beetles are predatory on many soil-dwelling pest species in agriculture and forestry.

Biocontrol advances In collaboration with the Lethbridge Research Centre, the taxonomy for two beetle species was determined. These insects are expected to help reduce losses from Canada thistle in western Canada.

The systematics of an important fly parasitoid, introduced to North America to help control the European earwig, was clarified. A related, native species of fly parasitoid was also discovered. It attacks native species of earwigs in the warmer zones of North and South America.

A large monograph of the world genera of the subfamily Eupelminae (Chalcidoidea: Eupelmidae) was published. Eupelmids are parasites of the eggs and larvae of many diverse insects and spiders. The publication, representing the final part of the work, establishes a means to identify and manipulate eupelmids from anywhere in the world for beneficial purposes in agriculture and forestry.

Advances in insect identification The Canadian fauna of planthoppers is poorly known, and identifications have been difficult or impossible. This year 8000 specimens of planthoppers in the Canadian National Collection were identified, resulting in many new records and more than 50 species new to science. These planthoppers include some of the most serious pests of cereal crops in the world.

A detailed study of the male genitalia of Diptera was completed. The work resolves 30 years of scientific confusion over the most important diagnostic character system used to identify flies. The study establishes the male genitalia as the major classification tool within the order.

An agreement was established with the U.S. Department of Agriculture to collaborate in developing a database of the world scale insects (Coccoidea). The software database for cataloging this group was developed at the centre.

Wild relatives and crop species With respect to cereals, the following advances were made.

- Two new species of *Kengyilia*, a wheat relative growing in China, were described.
- New unit classes on the 5S DNA locus in barley and its relatives *Kengyilia* and *Roegneria* were discovered. The gene is fundamental for protein synthesis. It is also associated with disease-resistant loci.
- In ancestral barley, two additional classes of repeats were discovered.
- The *Triticale Register* was distributed on the Internet to seed traders, geneticists, plant breeders, and gene banks.
- An account of *Avena* (oats) species of North America, including wild sources of disease-resistance genes, was completed.
- The genetic relationships of wild relatives and the crop species of canola were determined. *Moricandia* and *Brassica* were shown to be closely related genetically. Germplasms of *Moricandia* will be useful in the breeding programs of *Brassica* and the canola crop species.
- The potential role of anthocyanoplasts and isozymes as chemotaxonomic and phylogenetic markers in the crucifer family was explained.
- The taxonomy of native species of cherries and Saskatoon berries was reviewed in connection with protecting germplasm resources of native crop relatives.
- Germplasm resources of the Gaspé Peninsula were reviewed.
- The status of a rare native sand cherry in the lower Great Lakes was clarified.
- A technique was developed to analyze DNA in strawberries. Scientists will use it to relate plants from different geographic areas and to correlate morphological characteristics with overall genetic variation.

Crop diversification Several activities are supporting diversification of crops in Canadian agriculture.

- Data on the pollination of ginseng in Canada is assisting seed production.
- Six articles were published on native medicinal plants with potential for expansion as crops in Canada.

- The alfalfa leafcutter bee, the world's second most important pollinator, was assessed for usefulness with diversified crops. The bee was found to be predictable. By managing the crop and the flowering vegetation surrounding it, producers can promote environmentally friendly agriculture that takes advantage of the free pollinating services of wild bees to generate crop seed.

Control of weeds Information on the spread of two invasive alien species of witchgrass weeds in southern Ontario and Quebec was published.

Biological data relevant to the control of two aquatic weed species were summarized to improve control and enhance utilization. These weeds are potentially harmful to irrigation and useful as fertilizer and livestock food.

The identification and geographical distribution in North America of 20 weedy crucifers was completed.

Forage systematics Results in this area included

- a description of a new species of fescue grass with a partially dioecious breeding system
- a database of seed and live-plant collections of perennial brome grasses from North America, including a source of useful genes for incorporating resistance to drought and cold in brome forage species
- a database on six species of forage sedges
- information on the identification and classification of bluegrass species
- ryegrass, spike-fescue, and oatgrass contributions to the collaborative reference manual of the grasses of North America.

Mycorrhizomes Radicchio depends on mycorrhizobia to augment its nutritive value. Its use increases the protein, sugar, and chlorophyll content of the leaves significantly.

The effect of various agricultural management practices on mycorrhizobium populations in barley fields was studied. Of interest was the number of species and the strength of the interspecific interaction. The global population of mycorrhizobium is not altered by any one treatment.

Contaminating molds Nucleic acid sequences have been established and then used to identify molds that occur in stored grain, in compost, and on roots of plants. Gene sequences confirm that some nephrotoxin-producing *Penicillium* species can be reliably identified using their mycotoxin profiles. Molecular techniques should lead to rapid and reliable means for routinely identifying these taxonomically complex fungi.

The third annual food and airborne fungus course was jointly conducted in Ottawa by

- centre staff
- the Netherlands Central Bureau voor Schimmelcultures
- Food Production and Inspection Branch, Agriculture and Agri-Food Canada

The course is based on research on contaminating molds. It is aimed at assisting industrial or regulatory personnel from Canadian and American companies and government institutes.

Harvesting wild mushrooms commercially Collaborative research has documented the quantities of commercially harvestable wild mushrooms in eastern Canada. A previously unrecognized species of western chanterelle, *Cantharellus formosus* Corner, is the principal marketed commodity.

A novel discovery Biodiversity research on macrofungi was supported by British Columbia's Department of the Environment, resulting in works published by Environment Canada. Featured as a scientific breakthrough was the discovery of mushroom fruit bodies seemingly grafted on other mushrooms. The interpretation of this finding was published by the weekly science journal *Nature*.

Cellulose digestion in cattle A worldwide monograph was published on the rumen and gut fungi essential for cellulose digestion in cattle and other herbivores. These anaerobic organisms are currently being studied internationally and in Canada by animal scientists. This scientific contribution will serve as a standard for their identification.

Low-temperature rot of apples Samples of fungi (Basidiomycotina) linked to low-temperature rot of apples in controlled-atmosphere storage were obtained in the Okanagan Valley of British Columbia. These were documented in the first available North American monograph for the wood decay fungal family (Basidiomycotina), published in support of the forestry sector.

Plant Genes Resources of Canada (PGRC) In April 1996, management of PGRC will be transferred to Saskatoon Research Centre. Canada's PGRC genebank preserves collections of

- cereals
- vegetables
- oilseeds
- forages.

In 1995, PGRC

- increased 3569 lines of wheat with the Cereal Research Centre in Winnipeg
- received and accessioned 2339 lines
- forwarded 7539 lines to clients and other genebank nodes
- organized descriptors of 18 000 lines of seeds for eventual shipment to Saskatoon
- updated information on the database for seeds and plant genera, leaving seven large important genera to be completed
- completed greenhouse regeneration of seeds for 200 older lines of barley
- established a home page on the Internet.

Biocontrol research support To facilitate and promote national and continental programs for biological control of weeds and insects, this group provided

- centralized scientific services
- advice
- publications
- parasitic species, free from hyperparasites, delivered to field research sites across Canada.

Biological Resources Division Identification Service During 1994, the division identified

- 5963 specimens of insects, mites, spiders
- 2610 vascular plants
- 1724 fungi.

Major clients for this service were

- Agriculture and Agri-Food Canada
- provincial departments
- Natural Resources Canada
- other federal departments
- Canadian universities.

Taxonomic Information Systems (TIS) This new unit aims to highlight the agricultural relevance of the results of biosystematics research. TIS released its first electronic publications on the World Wide Web in July. Products developed in the first 6 months include

- Biosystematics Research Division's home page on the Internet
- an electronic version of the technical bulletin *Lygus bugs on the Canadian prairies*
- a searchable database, *Beetles of Canada and Alaska*
- an interactive key to *Fusarium*
- two slide shows
- a brochure
- a poster
- Agrinet Central, a set of search tools to all of the public information stored in hypertext format on the various servers maintained by the branches on Agrinet.

National standards for soil inventory Field work was completed for detailed soil mapping in

- Quebec (St.-Jean County, Ile Ste-Thérèse)
- Ontario (Rural Municipality of Waterloo and Oxford County)
- New Brunswick (Shediac - Botsford region)
- Newfoundland (Flat Bay area)
- Manitoba (one-third completed)
- Saskatchewan (nine rural Municipalities were mapped in 1994 - 1995 and 19 in 1995 - 1996)
- Alberta (a further 6.6 million ha or 204 townships).

Canadian Soil Information System The following results were achieved:

- A new version of the *Soil Landscapes of Canada* database was prepared and distributed via the Internet.
- Statistics Canada's database on the *Census of Agriculture* was linked to the *Soil Landscapes of Canada* database. Agricultural statistics can be analyzed by soil type and soil properties.
- A new map, the *Peatlands of Canada*, has been prepared with the Geological Survey of Canada, Natural Resources Canada. The map is based on data in the national soil database, supplemented by information from other federal and provincial sources.

Land resource data applications A land-suitability rating for spring-seeded small grains was published. The system can be used to assess crop production potential in general. The system is being developed to assess land suitability for specific crops such as canola, potatoes, or fruit.

Soil-quality benchmark site network Scientists are tracking changes in soil quality over time, as a result of farming practices. Twenty-three detailed sites have been

- selected
- mapped
- sampled
- instrumented
- described.

Already, significant changes in soil organic matter and pH have been detected at some sites.

Analyses of soil and environmental quality Information was prepared for use in the *1996 State of the Environment Report* (Environment Canada). It showed the biophysical role of agricultural activities in the Great Lakes - St. Lawrence Lowlands Region. Increases in crop production over the past 10 years are closely correlated with areas of superior inherent soil quality, indicating minimal environmental impact. The concept of an indicator for risk of water contamination by agricultural practices has been described, and a proposed methodology was demonstrated.

Health of Our Soils: Toward Sustainable Agriculture in Canada Sustained, high-intensity, high-quality agricultural production in Canada requires a means for measuring, monitoring, and maintaining soil health at appropriate levels. This report

- defines soil health and its components
- identifies the main soil health problems in Canada
- assesses the present status of soil health in Canada
- examines the present and expected future trends in soil health
- suggests solutions to soil health problems.

LEACHM model application Use of this model was extended to estimate, under Canadian conditions, the water content and hydraulic head regardless of whether soil macropores are water-conducting or air-filled. Its accuracy was verified, making it useful for predicting movement of water, fertilizer, and pesticide through the soil profile and into ground water resources.

Biofilters Bacteria capable of rapidly degrading the herbicide atrazine were found in surface sediments of tributaries and creeks in an agricultural watershed in southwestern Ontario. This finding suggests that mechanisms may evolve naturally to reduce pesticide levels in lakes and streams.

Micrometeorological measurements to gauge farming practices Scientists are quantifying the effects of farming on the environment and vice versa by measuring small changes in the atmosphere, specifically:

- CO₂ levels in the air above a maize crop correlated with soil temperature and the dose of manure applied
- 30% of the carbon contained in the applied manure was lost during the growing season
- N₂O fluxes were highly episodic, with peaks occurring after manure application and rainfalls
- uptake of atmospheric methane by a humisol was inhibited by high moisture content
- nitrate fertilization did not inhibit methane uptake but stimulated the production of nitrous oxide carbon
- isotopic composition revealed multi-directional methane movement in peat profiles
- differences in the oxidation rates of soil carbon between soils under conventional and conservation tillage were related to differences in soil temperature and soil moisture
- an estimate of the net exchange of CO₂ between Canadian soils and the atmosphere indicates that agricultural soils in Canada were a net source of 7.22 Mt of CO₂ in 1990. Even though the carbon exchange in most of the agricultural soils are close to an equilibrium, the losses are equivalent to 69% of the present annual amount of CO₂ released by the burning of fossil fuel used on farms in Canada.

Agrochemicals The relaxed eddy-accumulation technique is an excellent technique to measure the flux of agrochemicals. Tower-based measuring systems for trapping agrochemicals were developed, using either polyurethane foam plugs or mini-tubes filled with a resin. Thermal desorption of resin simplified the analysis of agrochemicals and improved the accuracy of the flux measurements. With the herbicides studied, vapor fluxes highly synchronized with soil evaporation rate. Maximum fluxes occurred on the day of herbicide application. Trifluralin and triallate fluxes on the day after spraying were approximately three times less than the previous day. These new technologies were also used to develop and validate an air - soil exchange model for agrochemicals.

Several bound pesticide residues in soil and food commodities were characterized using new methodology. Research to determine pesticide residue formation with deltamethryn and methyl-parathion and the bioavailability of the bound (nonextractable) residues to plants and animals was completed. This information supported pesticide-regulatory decisions related to environmental quality and food safety.

A genetic transformation of soil bacterial strains was carried out using a new and improved *Rhodococcus* - *Eschericia coli* shuttle vector with multiple cloning sites. Two independently isolated *Rhodococcus* bacteria were shown to degrade s-triazine herbicides. Our isolated soil bacterium that degrades thiocarbamate and atrazine pesticides was also effective for biotransformation of the insecticides carbofuran and carbaryl. These results suggest that multi-pesticide degradation capacities could be genetically engineered into selected soil bacteria.

A reliable, easy method for assessing compost biomaturity was developed. In consultation with industry, we designed a program that assesses the benefits of applying composted municipal and industrial solid waste to agricultural lands.

Soil quality evaluation program The results of Agriculture and Agri-Food Canada's program were published. The report

- identified and described the main problems of soil degradation
- assessed the present status of agricultural soil health in Canada
- evaluated trends in soil health over the past 10 years
- predicted future trends.

Soil organic matter Collaboration between the department and Institut National de la Recherche Agronomique in France is expected to foster joint studies on the effects of organic amendments on soil quality.

A newly developed technique using stable carbon isotopes enabled scientists to accurately quantify the amount of soil organic matter derived from corn. They also estimated the turnover rate of organic matter in bulk soil and in soil density and particle size fractions. At two locations in Ontario about 25 - 30% of the soil organic matter in the plow layer was derived from corn in fertilized soils. The proportion was lower in unfertilized soils. Fertilization did not alter the decomposition of soil organic matter. About 15 - 25% of the total corn residue inputs remained in the soil after more than 25 years of continuous corn cropping.

New instrumentation Two instruments (patents pending) have been developed for commercialization:

- a portable mechanized soil penetrometer that measures simultaneously the soil strength and its water content
- a new winter precipitation gauge.

Crop management aids The following aids are available for producers:

- optimum seeding periods for winter wheat in various climatic zones in Ontario, published in the 1995 - 1996 *Field Crop Recommendations*
- detailed statistics on heat units available for corn, soybean, and other warm-season crops for 50 locations in Ontario at weekly intervals, using data from the 1961 - 1990 period.

A new thermal index was developed for corn. It improves estimates of maturity dates by 45% over growing degree days or crop heat units.

The simultaneous heat and water model was successfully calibrated and tested. It takes observations of soil temperature and water from planting to emergence of corn on conventional and no-tillage plots.

Alfalfa may not always be a viable means of rebuilding soil structure that was lost through corn cropping. Although within 1 - 2 years alfalfa was effective in restoring the structural quality of a degraded clay loam soil that had been under continuous corn for more than 25 years, virtually all the improvement was lost within 1 year of reintroducing corn production.

More effective water management Scientists have improved methods for measuring

- soil hydraulic properties
- field-saturated hydraulic conductivity
- matric flux potential.

These methods potentially allow for more effective design and performance assessment of

- irrigation and drainage systems
- septic tank leach fields
- landfill caps and liners.

Soil conservation and crop productivity on the farm A prototype expert system was developed as an operational tool for diagnosis and prognosis of farm conditions, integrating

- farmer knowledge
- GIS-based land resource information
- long-term scientific research.

The system evaluates the impact of erosion by estimating yield reductions. Based on practices judged to be economically efficient by innovative conservation farmers, it lists

- recommended ameliorative practices
- expected improvements in productivity associated with each practice.

Photosynthesis efficiency New methods were developed to calculate photosynthate production and movement of sugars from leaves to stem for different types of plant canopies. They will help researchers to better understand phenotype - yield interactions.

A model was developed to calculate effects of N concentration and light intensity on leaf photosynthesis. The results permit ranking of nitrogen-use efficiency among cultures.

Land use analysis and remote sensing Imagery research produced the following results.

- With ground-based microwave imagery, radar-look direction relative to tillage direction is important for tillage monitoring.
- Crop rotation identification in the field and over a series of years is feasible and accurate using visible and infra-red imagery, providing that cloud-free imagery is available at the height of the growing season.
- Radar imagery can be used to resolve the cloud problem, but the method requires six times the processing and three times the cost.
- Radar can provide estimates of near-surface soil moisture, but surface roughness can affect the accuracy of the results.
- Estimates of crop and land cover from satellite vary little from data reported in the census in areas of intensive farming and high-quality resources, but diverge more in areas where farming is less intensive and resources are of lower quality. Neither source of data by itself is adequate for land evaluation purposes.
- A physical radar backscatter model was tested against optical data taken over three different surface roughness treatments. Microwave assessment of surface roughness, when used with the model, seems to provide accuracy superior to conventional measurements.
- A procedure for reconfiguring data from an administrative spatial base to a biophysical stratification is now available for application.
- Analysis of ground data and a variety of imagery taken by SIR-C/X-SAR showed that estimates of soil moisture are significantly affected by the incidence angle of the sensor. This finding is important since RADARSAT takes images of the same scene under different incidence angles.
- Digital yield maps obtained from precision farming are ready to be integrated with detailed soil and tillage data.

Agro-environmental indicators Analyses of trends of soil cover and management for the years 1981 and 1991 indicated that

- soil conservation actions reduced the amount of bare soil and fallowing in Canada
- regional trends varied and were mostly related to shifting cropping patterns
- soil erosion risk was reduced.

A framework was developed for a soil ecological index - indicator for monitoring the distribution of soil organisms in varying soil conditions. The indicators are to be used to monitor change in agronomic practices, such as in converting from conventional tillage to a no-till system.

The LANDS (Land Analysis and Decision Support System) was favorably reviewed by the Université Laval. It will be tested operationally in evaluating the impact of agricultural production systems on ground water quality. Progress was also made in commercializing LANDS. In a matching investment research initiative with the Engineering and Statistical Research Institute of Canada, the design and data model concepts used in the LANDS system are being evaluated for application to a commercial decision support system.

Mycorrhizal soil fungi Inoculum applied at seeding caused a 20% increase in corn yields. This technology is expected to improve production efficiencies.

Wheat mycotoxin detection, quality, hardness, and transformation Two tests for detecting contaminants in grains were developed:

- monoclonal antibody-based immunological test, which detects rapidly the mycotoxin deoxynivalenol in wheat and corn
- three DNA probes used separately or in sequence to identify and quantify specific mycotoxin-producing *Fusarium* species in cereals.

The immunoassay method is as efficient, and possibly more accurate, than the lengthy and expensive chemical methods used currently. A kit developed by Editek Inc. based on our technology, is now being marketed in North America by Diagnostix Inc., Mississauga.

Dipix Technologies, Inc. (Ottawa) have signed a collaborative research agreement to verify and modify spectral imaging methods for measuring grain and flour quality in wheat.

A transformation procedure, using a corn anthocyanin gene as a selectable marker, has been developed. The anthocyanin pigment can replace herbicide- or antibiotic-resistance genes as selectable marker traits in plant-transformation systems.

Forage grasses tolerate ice encasement better than other crops. Comparisons with winter wheat have revealed a different metabolic strategy for survival in ice.

A 5-year collaborative research agreement has been signed with W.G. Thompson and Sons Ltd., Blenheim, Ont., to develop soft red and soft white winter wheat varieties for southern Ontario that are resistant to fusarium head blight. All varieties grown today are susceptible to the disease.

Corn breeding, fusarium resistance, mycotoxins, and cold sensitivity Twenty inbred lines of corn with diverse genetic background and superior combining ability were released to the seed trade in North America. Several of the inbreds have resistance to *F. graminearum* infection via the silk. All lines have had 8 years of intensive selection for resistance and were also evaluated for resistance by crossing with susceptible tester lines. Resistance was dominant in the combinations.

Strains of *Fusarium moniliforme* and *F. proliferatum*, isolated from corn across Ontario, produce fumonisins and fusarins in culture media. In conjunction with the Ontario Ministry of Agriculture, Food and Rural Affairs,

fumonisin was found in some Ontario corn in 1993 at concentrations up to 2.5 µg/kg. Such levels are known to affect swine productivity.

Chilling susceptibility in corn at early growth stages is associated with reduced activity in the leaves of

- three antioxidant enzymes
- the antioxidant compound β -carotene.

This finding provides the basis for a selection procedure to improve the tolerance of short-season corn to low temperature.

Barley breeding, molecular markers, and diseases Two six-row barley cultivars were released for Eastern Canada, in cooperation with the Charlottetown Research Centre.

- DB169, licensed to AgroCentre Belcan, Vandreuil, Quebec, has higher yield than Leger and Chapais. It is the only cultivar recommended for the Maritimes with resistance to powdery mildew.
- AB151, licensed to Advantage Seed, Inkerman, Ontario, has high yield across Eastern Canada. It is more resistant than Chapais to numerous diseases.

A barley doubled-haploid population derived from parents contrasting for scald resistance has been developed. One parent, CI9831, has shown reduced susceptibility to fusarium infection.

Molecular markers have been identified that can distinguish between the morphologically identical barley cultivars AC Hamilton and Leger.

Oats industry collaboration and genome mapping Quaker Oats of Canada Limited, Peterborough, Ont., have renewed a 5-year \$1.1 million collaborative research agreement. The aim is to continue development of molecular markers to identify specific traits in oats.

The first molecular-linkage map of cultivated oat has been published. This map contains 461 loci. It is the result of collaboration between the centre and three American universities that comprise the Quaker Oats Oat Genome Mapping Consortium. This map is also available on the World Wide Web in the GrainGenes database.

The map and the many ongoing projects on the development of molecular markers for oats provide powerful new tools for developing new improved oat cultivars.

Soybean breeding and transformation Advances in soybean breeding include

- five new small-seeded cultivars registered and released to companies in Eastern Canada, with improved characteristics for production of the soy food natto
- field trials on short-season Canadian varieties of transgenic soybeans produced with an *Agrobacterium*-based transformation method
- the finding that in short seasons, lines of soybean with tawny pubescence yield more seed than those with gray pubescence
- the filing of patents for promoters that drive genes carrying agronomically important traits, such as for seed coat, stamen, pistil, pollen, and low-temperature tolerance.

Forage, genetic engineering, hybrid alfalfa, and nitrogen fixation Elite germplasm suitable for use in hybrid alfalfa seed production was generated from crosses between in vitro regenerating lines and material with multiple disease resistance. This material is available for use by private and public plant breeders. Part of the germplasm, developed in collaboration with AgrEvo Canada Inc., also carries a resistance gene for tolerance to the herbicide Ignite.

Alfalfa plants derived from embryogenesis can be cold hardened to withstand temperatures less than -5°C without any plant mortality caused by freezing. Storing and transporting plants in a frozen state reduces plant mortality and facilitates establishment of plants in fields for hybrid alfalfa seed production.

Stable cloning vectors were constructed for the genetic engineering of rhizobia. Technology for the genetic improvement of *Rhizobium meliloti* inoculant strains for alfalfa was transferred to the Canadian industry.

A 3-year project was completed involving the first release and tracking of genetically modified bacterium in Canadian soil.

Resources

The Eastern Cereal and Oilseed Research Centre (ECORC) was created in April 1996 by amalgamating programs from the former Centre for Land and Biological Resources Research and the Plant Research Centre. It is located in Ottawa on the Central Experimental Farm (CEF).

The centre houses reference collections including

- Canadian National Collection of Insects, Mites, Arachnids, and Nematodes
- Canadian Collection of Fungus Cultures
- National Mycological Herbarium
- departmental Vascular Plant Herbarium.

Also located at the centre are

- National Identification Service, dealing with specimens of insects, mites, spiders, nematodes, vascular plants, and fungi
- National Soil Database
- Canadian Soil Information System.

The centre is responsible for operations on the 500-ha CEF, including maintaining

- the Arboretum
- the Ornamental Gardens
- growth facilities
- experimental fields for CEF establishments.

The centre's staff of 473 full-time equivalents includes 148 in the professional categories. The centre manages a budget of \$28 million. By 1 April 1997, these figures will be reduced to meet the target specified through program review.

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Mandate

The lead site of the Cereal Research Centre at Winnipeg develops superior wheat and oat cultivars for the Canadian prairies. The centre supports cereal breeding programs at research centres across western Canada with research in

- cereal genetics
- plant pathology
- cereal chemistry
- quality evaluation
- biotechnology.

At Winnipeg researchers also

- develop improved methods to maintain the quality and safety of stored grain and grain products
- provide screening for regional disease resistance and quality to cereal development programs for the prairies.

At Morden researchers develop improved cultivars and better production and protection practices for the prairie region for flax and field peas. Researchers also

- conduct crop quality research to enhance the marketability of these crops
- develop landscape plants for the prairies
- maintain germplasm of alternative crops and winter-hardy woody ornamentals.

Achievements

- *New hard red spring wheat cultivar*
- *Advances against leaf rust in wheat*
- *Fungicide treatments for wheat*
- *Cooked pasta disc viscoelasticity (PDV)*
- *Identifying plant genes*
- *A tan hulled oat cultivar*
- *Genetic resources*
- *Privatization of buckwheat breeding*
- *New flax cultivar*
- *New sources of resistance*
- *Reaction of field peas to powdery mildew*
- *Biocontrol for field peas*
- *Joint development of field pea cultivars*
- *Maintaining resistance to crown rust in oats*
- *Identifying new resistance genes*
- *Stem rust races*
- *Genetic markers in biotechnology*
- *Controlling insect pests of oilseeds*
- *Controlling storage pests with carbon dioxide*
- *Controlling rusty grain beetles*
- *Pirimiphos-methyl for control of storage pests*
- *A natural grain protectant*
- *Storing yellow mustard seed*
- *Penicillium toxins*
- *New cultivars of landscape plants*
- *Asexual propagation of jack pine*
- *Computer simulation for green ash*
- *Estimating seed water content in field pea*
- *Reduced tillage in potato*

New hard red spring wheat cultivar The line BW 173 was approved for registration and will be distributed by Cargill as AC Majestic. This high-quality, hollow-stemmed variety offers

- 7% higher yields than Katepwa, the most widely grown prairie variety
- short, strong straw
- excellent sprouting resistance
- good disease resistance.

It is adapted to the whole wheat-growing area of the prairies, but its better straw strength is of greater significance in moister areas.

Advances against leaf rust in wheat Two genes for leaf-rust resistance were transferred from a wild emmer wheat accession to hexaploid wheat by a series of backcrosses. One of the genes may be new. It gave excellent resistance to leaf rust and should increase the genetic diversity available to wheat breeders.

Leaf-rust phenotypes with virulence to previously effective resistance genes increased in some cases to 40 - 60% in 1993 in Manitoba and Saskatchewan. The prevalent phenotype in Quebec and Ontario remained unchanged. Recent wheat varieties developed for the eastern prairies have at least two effective resistance genes that interact to confer high levels of resistance.

Leaf rust is one of the most damaging diseases of wheat in Uruguay. During 4 years, virulence phenotypes were identified. Phenotypes with virulence to *Lr26* increased over the period. Certain virulence phenotypes were distinct from those reported in North America.

All stem rust races isolated from wheat in western Canada in 1993 were tested for virulence or avirulence to the *Sr* series of genes in wheat and cultivated barley. There were no major race changes in stem rust on either wheat or barley.

Fungicide treatments for wheat The leaf pathogen *Septoria nodorum* in wheat grains causes

- shriveling
- reduced yield
- lower thousand-kernel weight
- lower dry root weight.

With adequate moisture, shriveled wheat yielded as well as plump seed. Fungicide treatment improved field emergence but did not increase yields or thousand kernel weight.

Fungicide treatments improved germination and emergence of seed from plants affected with fusarium head blight, especially at cool temperatures. Root dry weight from fusarium-affected seed was significantly less than that of nonaffected seed.

Cooked pasta disc viscoelasticity (PDV) In tests with durum semolina, PDV correlated with

- mixograph mixing characteristics
- sedimentation volume
- cooked gluten viscoelasticity.

However, PDV did not correlate with protein content. Until a better test is available, PDV will be useful in durum breeding programs because it

- uses small samples
- is simple
- closely mimics rheological tests of pasta, the final product.

Identifying plant genes RNA specific to flame chlorosis disease was detected and analyzed with high sensitivity using

- RT/PCR amplification
- specific hybridization to a nonisotopically labeled riboprobe.

This technique was further exploited to detect inducible genes. It should have a wide range of uses in identifying plant genes directly at the molecular level.

A tan hulled oat cultivar OT275 was supported for registration and will be distributed as AC Assiniboia by Proven Seeds in western Canada and by C&M Seeds in eastern Canada. It has

- improved crown rust resistance in all rust areas of the prairies
- improved resistance to Barley Yellow Dwarf Virus.

In all other respects it is similar to Robert oat in having

- high yield
- good lodging resistance

- high protein
- low percentage of hull.

OT275 is aimed at the high-quality food market. Tan hull is now accepted by the racehorse market in Manitoba.

Genetic resources A survey of Canadian wild plant germplasm was completed. Approximately 30% of our native species are related to economic plants (excluding landscape plants), indicating their value and importance as a genetic resource.

Three new publications were prepared:

- a comprehensive listing of plant performance at Morden Arboretum
- the Prairie Regional trials (1959 - 1993)
- a checklist of woody potentilla cultivars. The centre is the international registration authority for *Potentilla fruticosa*.

A survey of bee-foraging activity was done with the University of Michigan on several species in the Morden genetic resource collection. Two excellent bee forages were identified:

- *Agastache*
- *Tilia* (linden).

Over 1500 lines of various species were grown for assessment and rejuvenation, including

- 153 flax
- 454 field peas
- 732 lathyrus
- 69 proso millet
- 74 foxtail millet
- 47 canary seed lines.

These lines will be included in our long-term seed storage program.

Privatization of buckwheat breeding The buckwheat-breeding program was turned over to Kade Research Ltd. in 1995. Dr. C. Campbell, formerly with Agriculture and Agri-Food Canada, will continue a buckwheat-breeding program at the centre. A royalty-sharing agreement has been signed.

New flax cultivar AC Emerson (FP 935) was registered in 1994 and distribution rights were awarded to the SeCan Association. The cultivar has

- high oil quality
- medium - large seed size
- chlorosis tolerance, making it particularly well suited to the calcareous soils of Manitoba.

It was high yielding in both early and late seeded tests in the Black and the Brown Soil zones of Manitoba and Saskatchewan.

New sources of resistance Sources of resistance to *Fusarium* wilt in flax were identified in recent plant introductions. The genetics of resistance in these new sources is under investigation and will be incorporated in new flax cultivars.

Sources of resistance to *Sclerotinia* seed and seedling rot were identified in field pea. These sources will be incorporated in the pea-breeding program to improve the resistance of future cultivars to this disease.

Field pea lines were identified with resistance to other diseases. The following lines will form the basis for developing resistant cultivars for western Canada:

- 44 moderately resistant to *Ascochyta* blight
- 18 lines resistant to powdery mildew
- 18 lines resistant to *Sclerotinia* root rot
- 5 lines resistant to *Fusarium* root rot
- 5 lines resistant to *Rhizoctonia* root rot
- 9 lines resistant to *Fusarium* wilt.

New sources of resistance to the predominant downy mildew race 3 in sunflower were identified. These sources will be released to the sunflower industry in royalty-paying agreements.

Reaction of field peas to powdery mildew An assay was developed to rapidly determine plant reaction to powdery mildew. Detached leaves are inoculated with conidia, incubated for 3 days, then assessed for disease reaction. Assay results were highly correlated with the reaction of whole plants.

Biocontrol for field peas A biocontrol agent was identified for control of root rots. Treating seed with ACM941 controlled root rot diseases and resulted in

- increased emergence
- higher fresh plant and dry weight
- better seedling stands
- increased seed yield.

The effectiveness of ACM941 for control of root rot diseases in field pea was equal to or better than Thiram, the only fungicide registered for seed treatment for pea in western Canada. This biocontrol agent has significant potential to reduce dependence on traditional chemical seed treatments in field pea.

Joint development of field pea cultivars A collaborative agreement with Danisco Seed, Denmark, was negotiated for developing cultivars suited to Canada and Europe. Danisco Seed has recently registered several field pea cultivars in Canada. This agreement will allow early access to germplasm that offers

- high yield
- early maturity
- improved lodging resistance.

Maintaining resistance to crown rust in oats Oat cultivars with genes *Pc38* and *Pc39* were highly resistant to crown rust when first released during the 1980s. In 1993, 47.3% of the crown rust races common in Manitoba were virulent to both these genes. In Ontario, 58.6% of the races were similarly virulent. Virulences to *Pc48* and *Pc68* were not detected in Ontario and were at low frequency in Manitoba. A newly-derived gene, *PcS42*, is highly resistant to all races, and gene *PcA* from an Italian accession is resistant to 86% and 98% of the races in Ontario and Manitoba, respectively.

Identifying new resistance genes Tests were done to determine the stem and crown rust resistance genes present in the common oat selection Wisconsin X1588-2. Only gene *Pg10* appears to confer a moderate but very broad range of resistance that may be useful in oat breeding.

Stem rust races A barley-virulent race of stem rust, QCCJ, was the most common race in stem rust collections from cultivated barley in western Canada. QCCJ has increased steadily since 1988. It is a continuing threat to barley in the rust-prone region of the prairies. In oats, the races NA27 and NA29 were the most common, but they are avirulent to the resistance genes in oat varieties now used in western Canada.

A mutation induced in the common wheat cultivar Canthatch results in resistance to several races of stem rust. Rust tests confirm that this mutation behaves as a nonsuppressor and not as a resistance gene. It permits the expression of resistance to some races of stem rust normally inhibited by a suppressor located in the same area.

An inoculator that quantitatively applies a spore - oil mixture on single stems or leaves of cereal plants was constructed. In tests using stem rust spores, distinctions between resistant and susceptible barley genotypes could be made using quantitative inoculations, when qualitative differences were not detectable.

Genetic markers in biotechnology DNA markers tightly linked to two leaf rust resistance genes in wheat were identified by combining

- the random amplified polymorphic DNA (RAPD) technique
- the denaturing gradient gel electrophoresis (DGGE) method of fragment separation.

These DNA markers will allow the rapid pyramiding of resistance genes into wheat cultivars through breeding programs that use marker-assisted selection.

Differential display reverse transcription polymerase chain reaction (DDRT-PCR) was used to identify different mRNA species in two unique populations of canola. Numerous polymorphic bands were observed between untreated and methyl jasmonate-treated tissue. The method has the potential to identify induced, differentially expressed genes in plants.

Significant variation was detected between two microsatellite sequences in 16 wheat lines. Markers based on microsatellite sequence sites appear more informative on closely related germplasm than either RFLP- or RAPD-based markers. This method may provide a starting point for developing a point-of-delivery wheat class identification system.

Controlling insect pests of oilseeds Lygus bugs are important pests of canola in Manitoba. On average 3 - 5% of canola seed, and sometimes as high as 20%, is injured by lygus bugs. Only the second generation of *Lygus lineolaris*, the principle species in Manitoba, occurs on oilseed rape, and the eclosion and dispersal of reproductively active first-generation adults are well synchronized with the bud and flower stages of the host plant. Manipulation of seeding date to prevent infestation is not likely a practical pest management strategy.

In field studies, the potato aphid reduced yield by 20% or more in oilseed flax but had no effect on oil quality. Using current prices, economic thresholds for insecticidal control of the aphid were determined as

- three aphids per plant at full bloom
- eight at the green boll stage.

Use of growth-stage-specific sampling and economic thresholds maximizes the insecticidal benefits of the applications.

The digestive proteinases of three important pests of canola were characterized.

- Bertha armyworm and diamondback moth use a serine-like proteinase in digestion.
- Flea beetle uses both cysteine- and aspartic-like proteinases.

Cotyledons and first true leaves of canola contain inhibitory activity against these proteinases. The level of activity is, however, insufficient to provide resistance to the pests.

Flea beetles fed less on wounded or jasmonate-treated canola seedlings compared with untreated controls, probably because

- their cotyledons were tougher
- the protein content was lower
- the level of cysteine proteinase inhibitor was higher.

Viscosity of canola cotyledon extracts increased up to 25-fold following wounding or treatment with methyl jasmonate. Wound-induced defences in canola appear to be based on several relatively weak mechanisms mediated by jasmonates.

The waxless characteristic of canola leaves is recessive to the normal wax characteristic. Inheritance is consistent with the presence of two gene pairs. Manipulating these few genes may lead to the development of canola resistant to flea beetle, based on altered leaf surface wax.

The larval parasitoid, *Eurithia consobrina*, a potential biocontrol agent for Bertha armyworm, was evaluated for its

- host range
- distribution
- synchronization with host
- constancy
- abundance
- life history.

It was found to have the potential to fill a largely unoccupied niche in the parasitoid complex of Bertha armyworm and fit criteria for a successful biocontrol agent.

The following inorganic salts are effective in enhancing the toxicity of *Bacillus thuringiensis* subsp. *kurstaki* in Bertha armyworm larvae feeding on canola plants:

- potassium carbonate
- calcium carbonate
- sodium carbonate
- magnesium sulfate.

The cost of adding these chemicals to spray formulations at the concentrations tested ranges from 2.6 to 7.0 cents a litre.

Controlling storage pests with carbon dioxide In populations of red flour beetle, flat grain beetle, and rusty grain beetle exposed to carbon dioxide concentrations above 17% for 1 week

- no offspring were produced
- exposed adults had high mortality.

At 7.5% carbon dioxide for 1 week

- numbers of offspring were reduced by 43, 94, and 50%, respectively
- total population at 6 weeks was reduced 53, 84, and 19%, respectively.

These carbon dioxide concentrations are higher than have been found in infested nonairtight granaries. However, they are of the order found in localized areas resulting from insect and microflora respiration.

Dry ice in insulated boxes maintained high carbon dioxide concentrations for over 15 days, without replenishment, in grain-filled bolted-metal farm granaries. In the bottom portions of the grain, carbon dioxide concentrations stayed at 30% and the mortality of rusty grain beetles exceeded 90%. On average, about two-thirds of the insects in the grain bin were killed. Although not effective for unsealed farm bins by itself, carbon dioxide treatments may be useful as part of an integrated pest management approach to insect control in non-gastight storage.

Controlling rusty grain beetles The adult rusty grain beetle survives well in the cold. Ice nucleators reduce its cold tolerance. The bacterium *Pseudomonas syringae*

- raised the beetles' supercooling point from -17°C to -6°C
- increased mortality to 100% after 24 h at -9°C.

It was also effective after several weeks on warm grain. The fungus *Fusarium avenaceum* also raised the supercooling point but only increased mortality at -9°C to 33%.

Malathion-resistant strains of rusty grain beetles are now occurring. Resistant adults, both virgin and mated, live longer than susceptible adults. Since rusty grain beetle has a relatively long reproductive period and females with the longest lifespan produce the most offspring, life span is an important component of fitness in this insect. The malathion-resistance gene did not reduce fitness.

Pirimiphos-methyl for control of storage pests This insecticide remained active in stored wheat over 24 months. Most insects and mites could not survive. Seed germination and microflora were not directly affected.

A natural grain protectant Compared with controls, extracts of *Melia toosendan* bark repelled 50-90% of

- rusty grain beetle
- rice weevil
- red flour beetle.

The extract significantly reduced the fecundity of all three insect species. These results suggest that a natural grain protectant based on *M. toosendan* extracts may be feasible.

Storing yellow mustard seed In yellow mustard seed stored at 31°C and moisture content of 11%

- biochemical and mycological changes occurred after 28 days
- mold was visible by 63 days.

With reduction of moisture content to 9.8%, no off-odors or visible molds were present after 147 days.

Penicillium toxins A new system based on colony characters and secondary metabolite profiles confirmed the identities of 11 grain-inhabiting nephrotoxic *Penicillium* species, or their chemotypes. One species was newly discovered and had a unique metabolic profile. Of 142 *Penicillium* isolates from farm-stored cereals in western Canada, 102 were toxin producers.

Rabbit polyclonal antibodies were developed for a novel and specific immunochemical analysis for the mycotoxin citrinin. Recoveries of citrinin added to wheat flour at 0.2 - 2.0 ppm were quantitative. This immunoassay is the first for this major *Penicillium* nephrotoxin, which occurs in stored grains.

New cultivars of landscape plants Two new lily cultivars were released to industry:

- Northern Beauty
- Starburst Sensation.

These very floriferous cultivars are hardy plants for the prairie landscape.

Two new hybrids of black and Manchurian ash were named and released to industry:

- Northern Treasure
- Northern Gem.

They have excellent hardiness (zone 2) and good crown form, for use as shade or boulevard trees. These hybrids are the first reported between these two species.

A novel and new dwarf monarda, Petite Delight, was released to industry. This disease-resistant purple-flowered cultivar resembles a dwarf chrysanthemum but has highly fragrant foliage and flowers. The cultivar is well adapted to large-scale plantings.

A new flowering crab apple, Spring Bride, was named and entered into nursery propagation programs. This double-flowered white cultivar has pink buds. The pedicels are extremely short; flowers thus appear as a garland type effect, outlining the branches of the tree.

Asexual propagation of jack pine Propagation was successfully accomplished via in vitro culture of cotyledon explants. Refinement of the technology using conventional approaches enabled rooting of more than 30 cuttings per seedling. Field trials of rooted cuttings and seedlings from comparative families were established with Weyerhaeuser Co. in Prince Albert, Sask., to determine long-term performance.

Computer simulation for green ash Simulated models of shoot growth were completed. Developmental events that have not previously been described for this species can now be visualized, including:

- preformed bud contents
- neoformed growth.

Estimating seed water content in field pea Visible indicators were evaluated for determining the correct time to desiccate field pea. Assessing the percentage of brown pods by visual estimate was as effective an indicator as counting. Thirty percent seed water content occurred when 75% of pods have turned brown.

Reduced tillage in potato Field studies were conducted from 1991 to 1994 to evaluate reduced-tillage management systems for potatoes. Planting potatoes in cereal stubble may be useful for reducing wind erosion of the land after planting and before crop emergence. Reduced-tillage production systems did not affect tuber yield or processing quality.

Resources

The offices, laboratories, greenhouses, and controlled-environment plant-growth facilities of the Cereal Research Centre's lead site are situated on the Fort Garry campus of the University of Manitoba in Winnipeg. Field research is carried out at a 103-ha field site at Glenlea, 12 km south of Winnipeg. Glenlea operates only during the summer, but grain storage bins located there are used throughout the year for research on pests of stored grain.

At Morden, the new office and laboratory building includes

- research laboratories
- cold storage
- plant-processing units
- an improved phytotron
- greenhouse facilities
- a pathology containment laboratory.

Local agricultural inspectors from the Food Production and Inspection Branch and regional offices for the Prairie Farm Rehabilitation Administration are located in the new building at Morden. The land base covers 254 ha.

The centre has a staff of 144.3 full-time equivalents, including 48 in the professional categories. It operates with a total budget of \$9.1 million.

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Mandate

The Brandon Research Centre conducts research on production systems for beef cattle and swine. New cultivars of barley and corn are also developed through conventional breeding programs. The centre has a land resource management program, which is now undergoing expansion. The major focus of the Brandon Research Centre in the future will be as a national centre of excellence for the development of sustainable management systems for cultivated soils and crops in the Black soil zone of western Canada.

Achievements

- *Staff awards and honors*
- *New enzyme immunoassays*
- *Electronic ear tags in swine*
- *Diets for market pigs*
- *New malting barleys*
- *Early-maturing inbred corn lines*
- *Better efficiency with urea fertilizer*
- *Inhibiting nitrification*
- *Fertilizer use under reduced tillage*
- *Green manure*
- *Reducing herbicide costs*
- *Herbicides and water quality*

Staff awards and honors Dr. L.D. Bailey received the 1995 Robert E. Wagner Award by the Potash & Phosphate Institute of Norcross, Georgia. This award recognizes distinguished contributions to advanced crop yields through maximum yield research and maximum economic yield management. His research on efficiency of fertilizer use has led to improved management practices for a variety of crops.

Dr. C.A. Grant was presented the 1995 Young Agronomist Award by the Canadian Society of Agronomy. Her research in soil management, plant nutrition, fertilizer-use efficiency, and reduced-tillage systems has had tremendous impact on Canadian farming practices and the prairie agricultural economy.

Dr. Grant also received the 1995 Woman of Distinction Award for Agriculture by the Young Women's Christian Association (YWCA). She was honored for outstanding achievements in agriculture through research.

New enzyme immunoassays An enzyme immunoassay was developed and validated for the routine measurement of progesterone (a steroid hormone) in blood plasma and cell/tissue culture medium of cows, pigs, and sheep. A second enzyme immunoassay was developed for measuring another hormone in the prostaglandin family (prostaglandin F₂α) that is frequently monitored. Both assays have the analytical advantages of radio-immunoassays without the use of radioactive materials. Also eliminated is the need to dispose of radioactive wastes.

Electronic ear tags in swine An evaluation of electronic ear tags (Destron/IDI) indicated that the devices can be installed and recovered in pigs with relative ease. They can be used effectively for identification and data collection. The international standardization of electronic identification devices will expand their application to

- production systems
- packing plants
- export markets
- control of diseases.

Diets for market pigs The use of canola meal to partially replace soybean meal in diets for market pigs had no significant effect on live and carcass performance. Responses to high inclusion levels of canola meal appeared better with barrows than gilts. Feed wastage may be a problem as soybean meal is replaced, because canola meal tends to be relatively less palatable. Optimizing the use of canola meal in farm-mix diets will be possible, if attention is paid to maintaining diet quality.

The intake of creep feed by piglets may occur as early as 2 weeks of age but does not represent notable amounts until they are 21 days old. Total creep per litter and average daily intake per piglet tend to increase with litter size, but average weaning weight declines. Suckling piglets can be discriminating about creep diets. The relative cost is no guarantee of their selection. Replacing the creep, or equivalent diet, too soon after weaning can jeopardize starter pig performance and ultimately delay the age to market weight.

New malting barleys AC Buffalo became the first six-row, white-aleurone malting barley released from the Brandon Research Centre to receive interim registration. With comparable yield, agronomic performance, and malting quality to its American counterparts, interest in AC Buffalo is high in the United States. Distribution is being handled exclusively through the Ultrabred Division of Prairie Pools, Inc.

TR232 became the second two-row malting barley developed at Brandon to receive interim registration. One of the outstanding features of TR232 is its excellent malting and brewing quality, particularly malt extract. SeCan Association will distribute the seed of TR232.

Early-maturing inbred corn lines Two new inbred corn lines were offered for release to private industry. CB22 and CB23 are high yielding and have excellent combining ability. They should be useful as seed parents in the development of new early-maturing, high-yielding grain corn hybrids.

Better efficiency with urea fertilizer Using a urease inhibitor with seed-placed urea fertilizer reduces seedling damage and increases yield in zero-till barley. Urea is the lowest-cost, highest-analysis form of granular nitrogen fertilizer available in western Canada. However, the amount of urea that can be seed-placed without causing seedling damage is often too low to optimize crop yield. Although more testing is needed to determine whether the urease inhibitor is effective over a range of environmental conditions, this product shows promise for increasing the safety and efficacy of seed-placed urea.

Inhibiting nitrification Fall-applied urea and urea ammonium nitrate with N-Serve, a product that decreases denitrification and leaching by selectively blocking nitrification, increase both the yield and nitrogen content of barley straw and grain. Products that can inhibit nitrification may allow farmers to

- improve the efficiency of nitrogen use
- enhance economic returns
- reduce the potential for loss of nitrates from the root zone into the ground water.

Fertilizer use under reduced tillage In-soil banding of nitrogen fertilizer was more efficient than surface application under no-till than it was under conventional till. As well, surface application of ammonium nitrate was more beneficial than urea under no-till than it was under conventional till. These results were likely due to greater losses of urea through volatilization. By careful consideration of nitrogen placement, producers can maximize fertilizer use efficiency under reduced tillage management.

Green manure Various pulse crops are being evaluated as green manure for energy and soil conservation on the Canadian prairies. A good green manure crop should

- produce a relatively high yield of both straw and marketable seed
- be easy to plow down
- be relatively high in nitrogen.

This study shows Indian Head lentils to be a better choice for green manuring than Tangier flatpeas on Orthic Black Chernozem soils.

Reducing herbicide costs Increasing forward speed of travel may be an efficient method of reducing spray volume for the herbicides sethoxydim (Poast) and fenoxoprop-P-ethyl (Puma), provided that boom stability of the sprayer is not affected. These findings will assist producers in reducing rates and costs of herbicide application without diminishing the level of weed control.

Herbicides and water quality In herbicide trials, sodium bicarbonate antagonism of the postemergence grass herbicides clethodim (Select) and sethoxydim (Poast) was overcome by

- as little as 1% (v/v) of a 490 g/L solution of ammonium sulfate
- the fluid fertilizers 28-0-0, 10-34-0, and 12-0-0-26.

With such information, producers can minimize the adverse effects of water quality on herbicide performance.

Resources

Brandon Research Centre is one of the five original experimental farms established by the federal government through an act of Parliament in 1886. The land base covers 755 ha owned and 443 ha rented. The staff comprises 70 full-time equivalents, including 16 scientists. The centre operates on a budget of \$4.2 million.

The new office and laboratory building includes

- modern research laboratories
- computer-controlled environment chambers and greenhouses
- long-term cold-storage units
- a library
- conference rooms
- offices.

Local staff from the Prairie Farm Rehabilitation Administration and Food Production and Inspection Branch are also located in the building.

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Mandate

The Saskatoon Research Centre and its research farms bring a long-term commitment in crops research to the agri-food industry in western Canada. The Centre's deliverables are:

- improved varieties of oilseed and forage crops
- crop production and pest control practices for the Parkland region
- research to expand the utilization of Prairie crops.

Each program has strong input from biotechnology and chemistry. A component of the crop utilization research is located within the POS Pilot Plant Corporation in Saskatoon.

Achievements

- *Staff awards and honors*
- *Canola varieties*
- *Transgenic canola*
- *Brassica chemical content*
- *Canola disease*
- *Common root rot resistance*
- *Forage disease*
- *Oat fractionation*
- *Biological control of bertha armyworm*
- *Round-leaved mallow in strawberries*
- *Control of wild oats*
- *Trifluralin residues*
- *Weed database on CDs*
- *Cooperative learning centres*

Staff awards and honors Keith Downey, emeritus scientist, received two prestigious awards in 1995:

- the James McAnsh Award, from the Canola Council of Canada
- the International Award for Research in Rapeseed from the *Groupe consultatif international de recherche sur le colza*.

Both awards recognized Dr. Downey's contributions to agriculture, which include the development or co-development of 18 rapeseed and canola varieties. They also acknowledge his influence in the canola industry internationally.

D.A. Derksen, A.G. Thomas, G.P. Lafond, H.A. Loeppky, and C.J. Swanton, from Agriculture and Agri-Food Canada and the University of Guelph, won the Outstanding Paper Award from the Weed Science Society of America. *Impact of Agronomic Practices on Weed Communities: Fallow within Tillage Systems* was selected from roughly 150 publications as the winner.

Canola varieties Market surveys indicate most canola growers across the prairies in 1994 chose varieties developed by the Saskatoon Research Centre. AC Excel, which ranked first, was planted by 31% of producers in Saskatchewan and 33% in Manitoba. AC Parkland and Tobin were also in the top 10 canola varieties. Farm-gate receipts for 1994 from canola amounted to over \$2 billion, a sum approaching wheat for the first time.

Transgenic canola The first varieties of transgenic canola, developed cooperatively with private companies and incorporating broad-spectrum herbicide resistance, were registered for sale in Canada. Their production is currently contracted to meet international restrictions dictating that transgenic canola yields remain separate from the commercial flow, much of which is exported.

Brassica chemical content Seed meals of more than 30 *Brassica* genotypes were analyzed for

- sucrose
- galactooligosaccharides
- protein
- dietary fiber
- ash
- residual fat.

On average, yellow-seeded types contained more sucrose and protein, and lower dietary fiber, than brown-seeded types. The development of yellow-seeded *Brassica napus* varieties is now a breeding priority.

Canola disease Knowledge of *Alternaria* species infecting Brassicaceae crops and weeds has been compiled in a comprehensive reference for pathologists. Several aspects of the disease, ranging from infection to control, for four species of *Alternaria* are included.

Common root rot resistance Common root rot is a soil-borne fungal disease of cereal crops that causes annual losses averaging 10% of grain yield. The primary pathogen on the prairies is *Cochliobolus sativus*. The cultivars of spring wheat currently grown on the prairies have intermediate to moderate levels of resistance. Breeding for resistance to common root rot provides an effective way to reduce the impact of this disease.

Three spring wheat germplasm lines were developed with higher levels of resistance and with yield and quality similar to that currently available. Four interspecific germplasm lines were derived from a unique common root-rot-resistant wild goatgrass accession. All seven of these lines are registered with Plant Gene Resources of Canada, Ottawa.

Forage disease Production of meadow brome grass is increasing rapidly on the prairies. Unfortunately, a recent survey indicated that head smut occurred in 60% of meadow brome grass seed fields in Saskatchewan and Alberta. It occurred frequently in weedy fields infested with susceptible grass species, such as downy brome or foxtail barley. Several pathotypes may exist. The smut spores are probably long-lived in the environment. Smutted plants are less likely to overwinter than healthy plants.

The following seed treatments all controlled head smut, in both greenhouse and field trials:

- carbathiin
- captan
- thiram
- propiconazole
- hexaconazole.

Oat fractionation An oat fractionation process, involving two international patents, has been commercialized for production of cosmetics. The Canamino plant in Saskatoon is processing oats to separate a number of useful components. These include

- oat flour, used for dusting powders
- oat starch, replacing Italian talc
- hydrolyzed oat protein, for use in hair-care products
- finely milled oat bran, useful for its skin soothing, moisturizing, and anti-irritant effects and a component of facial muds, scrubs, and soap-free skin cleansers
- β -glucan, another product concentrated in the bran, which enhances the viscosity of skin-care products and is a moisturizer.

Biological control of bertha armyworm Larvae of the bertha armyworm reduce rapeseed and canola yields by eating the seed pods and defoliating plants. Biological control of the bertha armyworm by an ichneumonid wasp and a tachinid fly, two native parasitoid species, is being augmented by the braconid wasp *Microplitis mediator*, a European parasitoid. This wasp, which attacks young bertha armyworm larvae, has a short development time, permitting two generations a year. It is easy to rear in the lab and attacks a variety of hosts, allowing it to maintain high field populations during periods of bertha armyworm infestation.

Round-leaved mallow in strawberries Competition from round-leaved mallow is detrimental to strawberry establishment and can significantly reduce yield. *Colletotrichum gloeosporioides* f. sp. *malvae*, a mycoherbicide, successfully controls round-leaved mallow in strawberries.

Control of wild oats Wild oats remains a priority weed in western Canada. Over 7 years, granular triallate, applied in mid-October, reduced wild oat infestation and increased wheat yields by at least 29%, compared with untreated check plots. Incorporation in the autumn made no difference to control of wild oats when triallate was applied to standing wheat stubble. Incorporation of the herbicide increased yield about 15% but did not influence spring wheat emergence or subsequent development.

Trifluralin residues Trifluralin is used extensively in western Canada to control various broad-leaved and grassy weeds in some cereals and canola. Carry-over of residues following spring and fall applications was monitored to determine persistence and, hence, potential effects on succeeding crops at several Saskatchewan locations. During the first winter following fall application, only a small amount of activity was lost. By the second spring, the amount remaining was similar to that from prior-spring application. Residues account for approximately a third of the amount of the product applied; thus accurate records are essential to avoid damage to sensitive crops such as oats, planted subsequently in the rotation.

Weed database on CDs This computerized retrieval system on compact disks assists weed scientists to summarize existing Canadian weed-management data and evaluate research needs. The database, managed by the Expert Committee on Weeds, includes reports of chemical, cultural, and biological weed control strategies for the periods

- from 1976 to present for the western section
- from 1990 to present in eastern Canada.

Available in both English and French, this tool is expected to assist personnel in research, industry, extension, and regulation in developing effective weed-management practices.

Cooperative learning centres Three cooperative learning centres have been established in northern Saskatchewan to encourage interaction between researchers, producers, and extension personnel. All participants bring different strengths; all work together to solve problems and share their experiences. Between 1500 and 2000 producers, students, and agrologists visit these centres annually to participate in various activities.

Resources

The main office-laboratory building and the greenhouse-growth chamber complex are located on the University of Saskatchewan campus. Saskatoon is emerging as a major world centre for agricultural biotechnology and our location encourages collaboration with other research establishments, public and private. Importantly, it also allows graduate students to participate in our research programs. Offices, laboratories, and shops service the programs at Scott and Melfort. Total full-time equivalents comprises 48 professionals and 116 in scientific and administrative support. The centre manages a budget of \$10.8 million. The main laboratory building was recently remodeled at a cost of about \$6.0 million.

The centre has a 242-ha field site 5 km northeast of the university. The Scott Research Farm is 160 km west of Saskatoon, with a land base of 349 ha. Scott also manages field sites at Lashburn and Loon Lake. The land base at the Melfort Research Farm, 200 km northeast of Saskatoon, consists of 371 ha near the city of Melfort. In addition, Melfort operates another 390 ha of bushland pasture near Pathlow, under an agreement with Saskatchewan. The Regina research site is scheduled to close in March 1997.

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Mandate

The Semiarid Prairie Agricultural Research Centre (SPARC) has been designated as a national centre for research on dryland farming systems. It has the mandate to conduct research and development in

- resource conservation (land)
- cereals
- forages
- field crops.

Achievements

- *Farming for a better environment*
- *Soil improvement with legumes*
- *New triticale cultivars*
- *New alfalfa cultivar*
- *Disposal of oily wastes*
- *Phosphorus concentration in crops*
- *Fertilizer recommendations*
- *Soil acidification*
- *Water conservation*
- *Soil structural problems*
- *Wheat growth models*
- *Nine decades of increased wheat yields*
- *Emergence of wheat seedlings*
- *Red smudge and black point in durum wheat*
- *Control of Canada thistle*
- *Improving hat yields*
- *Short-duration grazing*

Farming for a better environment In a white paper prepared by the Soil and Water Conservation Society, scientists concluded that after conservation tillage practices have been in place for several years, the level of soil organic matter stabilizes at a new higher level. This phenomenon favors the continued productivity of soils into the future.

Soil improvement with legumes This bulletin, produced with Saskatchewan Agriculture and Food, informs producers on how to use legumes as an effective method to improve the quality of their soils.

New triticale cultivars AC Alta and AC Certa Canada triticales were registered. AC Alta is a high-yielding, large-kerneled, lodging-resistant cultivar that is widely adapted to the prairie provinces. AC Certa is the first spring triticale registered in Canada that combines high grain yield and high test weight with improved Hagberg Falling Number (it may be less prone to field sprouting).

New alfalfa cultivar A persistent, grazing-tolerant cultivar of alfalfa (*Medicago falcata* (L.) Arcangeli), released by Swift Current and Melfort, was approved for registration.

Disposal of oily wastes When oily wastes are applied to agricultural soils at moderate rates (0.5 - 0.7% by weight), the result is extensive improvements in soil structure, biological activity, and organic matter content of a sandy soil, without excessive negative environmental impact or reduction in grain production.

Phosphorus concentration in crops A long-term rotation study at Swift Current showed that the amount of P exported with the grain was higher for cereals (4.9 - 7.4 kg/ha) than for lentil and flax (3.3 - 3.7 kg/ha).

Fertilizer recommendations Data from the long-term rotation experiment at Swift Current has shown that reported variations in available P between spring and fall were spurious; thus, whether soils are sampled in fall or spring, soil testing laboratories need not adjust their P fertilizer recommendations.

In a long-term irrigation study the response of brome grass to current and previous applications of nitrogen (N) fertilizer was observed. Repeated annual applications of N fertilizer enhanced the N-supplying power of the soil. Similar results were obtained on a 12-year fertility study for continuously cropped spring wheat. If soil testing laboratories do not consider the fertilization history of the field, fertilizer recommendations may overestimate the fertilizer N requirements.

Soil acidification In a 10-year study the acidifying effects of anhydrous ammonia and urea in a Dark Brown soil were investigated. Anhydrous ammonia caused more soil acidification than did urea. Permanent acidification from N fertilizers occurs when fertilizer-derived nitrate is not used by the crop but is leached from the soil as a companion to calcium and magnesium.

Water conservation An eight-year tillage study in the Thin Black soil zone demonstrated that improved water conservation with conservation tillage increased grain yields of

- spring wheat
- flax
- field peas.

Soil structural problems A new laboratory method was developed to more accurately represent clay dispersion in the field as affected by sodium and other salts. This method shows that the risk of soil structural problems caused by an undesirable salinity - sodium balance was greater than previously assumed.

Wheat growth models The United Nations Global Change Terrestrial Ecosystems group has chosen southwestern Saskatchewan as the sole location in Canada for evaluation of wheat growth models that will eventually be used world wide. Canada will be an early beneficiary of this emerging technology.

Nine decades of increased wheat yields An historical analysis has shown that Canadian-developed cultivars have increased annual yields of hard red spring wheat by about 7.5 kg/ha for more than 90 years. The yield gains have resulted mainly from an increase in the number of kernels produced rather than through an increase in kernel size.

Emergence of wheat seedlings A simple method for assessing the impact of seedbed physical state on the speed and relative emergence of wheat seedlings was discovered.

Red smudge and black point in durum wheat Field and controlled-environment studies showed that red smudge

- reduced total emergence and rate of emergence of seedlings
- increased time to heading
- decreased number of spikes, dry weight, and grain yield per unit area.

Semidwarf durum wheat genotypes were found to be more susceptible to black point, and more resistant to red smudge, than the conventional-height genotypes.

Control of Canada thistle Integrating the effects of photoperiod and tillage on plant development permits doubling the control of Canada thistle while reducing the chemical application to only one-half of what was formerly required.

Improving hay yields Over 7 years, hay yields from alfalfa planted between windbreaks of tall wheatgrass averaged 33% more than those obtained in an adjacent, conventional open field. This yield advantage was due to the microclimate encountered between the windbreaks, where conservation of soil moisture from snow was increased and evaporation was slower. A special seed drill has been designed and constructed to make seeding of the grass windbreaks easier.

Short-duration grazing Early grazing (May) or deferred use of native prairie did not reduce range condition or productivity in subsequent years when a short grazing period was followed by a year's rest before next use. This short-duration grazing of native forage either during or after the spring growing period protected the habitat for wildlife and produced gains of 0.9 kg/day by yearling steers from May to August.

Resources

The Semiarid Prairie Agricultural Research Centre in 1995-1996 had 113 full-time equivalents, including 26 professional staff, has an A-base budget of \$7 million, and received about \$2.2 million from the private sector and from federal and provincial government targeted funding programs. The total land base is about 925 hectares in Swift Current, 535 hectares in Indian Head, and 53 hectares in Regina.

Facilities include a modern office-laboratory building equipped with

- growth rooms
- greenhouses
- a salinity research lab
- a crop services building
- a breeders' seed production and distribution centre at Indian Head
- a well-equipped machinery design and production facility.

Research Publications

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Mandate

The Lethbridge Research Centre produces new technology and information to help develop more competitive and sustainable production systems for rain-fed and irrigated cultivated land and rangeland in the southern Canadian prairies and the interior of British Columbia.

Crop research focuses on

- cultivar development
- pest and disease management
- agronomy of cereals, forages, potatoes, and some special crops.

Research on beef and dairy cattle emphasizes

- nutritional and reproductive efficiency
- pest management
- economics and rangeland management.

Management and conservation of soil and efficient use of water in the Brown and Dark Brown soil zones are the major objectives of soil and water research, which complements the research on commodities.

Achievements

- *Staff awards and honors*
- *Identifying soil erosion problems*
- *Remote sensing for soil conservation*
- *Minimizing tillage*
- *Soil and water quality*
- *Modeling wheat yield under climate change*
- *Assessing yield from irrigation*
- *Rate of return on wheat research*
- *Improving resistance to disease in cereals*
- *Reducing downy brome in wheat*
- *Controlling Russian wheat aphid*
- *Improving barley cultivars*
- *Disease control in beans*
- *Herbicide studies on field crops*
- *Combatting sclerotinia in field crops*
- *Improving safflower, canola*
- *New potato cultivars*
- *Plant Breeder's Rights*
- *Improving potato yields*
- *Disease control in potato*
- *Disease control in alfalfa*
- *Establishing forage*
- *Reproductive physiology in bees*
- *Biocontrol of weeds in forages*
- *Nitrotoxins*
- *Rate of return on beef research*
- *Reproductive performance in bulls*
- *Diet formulations for cattle*
- *Treating cattle feed*
- *Bloat-free alfalfa*
- *Ruminal microflora*
- *Ruminant digestibility*
- *Controlling insect pests of cattle*
- *Lambs*

Staff awards and honors The following scientists were honored during the past year:

- Dr. Karen Beauchemin received the Young Scientist Award from the Canadian Society of Animal Science
- Dr. Blackshaw was awarded the Outstanding Young Weed Scientist Award from the Weed Science Society of America
- Dr. K.-J. Cheng received the 1994 Canadian Society of Animal Science Award of Merit
- Dr. Larry Kawchuk was elected president of the Plant Pathology Society of Alberta. He was invited to address the United Nations 1995 Biotechnology Congress in Havana, Cuba

- Dr. Henry Huang was invited by the Hokkaido Government, Japan, to serve as adviser on biological control of plant diseases
- Dr. John Kastelic became one of only 300 people world-wide with the recognition of "Diplomate, American College of Theriogenologists"
- Dr. D.J. Major was elected president-elect of the Canadian Society of Agronomy.

Identifying soil erosion problems Soil losses caused by wind erosion were quantified for the first time in Canada. Total soil loss during a fallow period amounted to 144 t/ha. The annual loss of productivity for spring wheat associated with the removal of 1 mm of topsoil was 11 kg/ha. Tillage creates large nonerodible clods that protect against wind erosion. On direct seeded, zero-tillage land, which has no such clods, wind erosion may become a problem when the residue cover is jeopardized by drought or fire.

Remote sensing for soil conservation Russian wildrye and crested wheatgrass can be distinguished from native range on satellite images using radar backscatter. The surface roughness of reseeded grass stands continually increases because of inter-row soil erosion.

Minimizing tillage Combining cultivation and herbicides to control weeds on fallow can

- be cost effective
- reduce soil erosion
- increase soil water accumulation
- give greater wheat yields after fallow.

Soil and water quality Current and long-term cropping practices strongly influence soil structure and water properties. Compared with forage crops, lower water infiltration is observed with cropping systems that

- require annual cultivation
- have no perennial crops in rotation.

Seeded grasses can neither return nor maintain the chemical quality of soils, as well as does native rangeland.

In the dry prairies, including grass - alfalfa as an organic-amending crop in a crop rotation can be profitable when grain prices are low. When grain prices are higher, applying livestock manure in a wheat-only rotation was more profitable than including forages in the crop rotation.

In a surface irrigation study, scientists found:

- the herbicide hexazinone was detected in both surface runoff and ground water
- 2,4-D, bromoxynil, dicamba, mecoprop, MCPA, and diclofop were detected in the ground water, but not in surface runoff
- bromoxynil concentrations exceeded the Canadian drinking water guidelines in 11% of ground water samples.

Modeling wheat yield under climate change Five simulation models were compared using data from a long-term wheat - fallow rotation. EPIC was selected as the most versatile model for use in climate change studies.

Assessing yield from irrigation For production of wheat and barley, scientists compared similar total water depth for different water-application rates and intervals. Results:

- irrigation treatment did not affect wheat grain yields
- conventional barley grain yield was higher for conventional irrigation than for frequent light irrigation.

Rate of return on wheat research Research increasing wheat yield in Canada between 1962 and 1992 has generated an internal rate of return of 27 - 39%. Benefit-to-cost ratios for avoidance of loss as a result of Canadian wheat research were calculated to be:

- diseases, 6 to 1
- weeds, 12 to 1
- insects, 15 to 1.

Improving resistance to disease in cereals Image analysis procedures were used to quantify and correlate the effect of common root rot on the growth and discoloration of

- the subcrown internode
- crown roots
- seminal roots.

Thirty years of research on the physiology of snow mold resistance and its relationship to freezing resistance was summarized. The work provides future direction for the development of winter cereal varieties resistant to freezing and snow mold. Various strains of snow mold fungi were identified and differentiated unequivocally for the first time.

The source of high susceptibility to common bunt in the Canadian red wheats was determined. It is parental germplasm originating from the International Maize and Wheat Improvement Centre (CIMMYT). A molecular marker to identify wheat lines carrying the bunt Bt-10 resistance genes was identified. It is now used to increase the efficiency of screening for Bt-10 resistance. A screening test to identify differential lines with the Bt-genes 8, 10, and 11 was developed. These results will help breeders speed up development of bunt-resistant varieties.

Carboxin is the most widely used seed-treatment fungicide for controlling smuts and bunts in winter wheat. Researchers found it ineffective at the recommended rates when

- treated seed was planted late in the fall
- treated cultivars were highly susceptible to common bunt.

Reducing downy brome in wheat Including fallow or a spring broad-leaved crop, such as canola, in rotation with winter wheat reduced downy brome populations to low levels. Winter wheat production is thus feasible in such rotations, in areas where downy brome is prevalent.

Controlling Russian wheat aphid Chlorpyrifos is a nonsystemic insecticide. It contacts this pest within curled cereal leaves via

- rapid vapor action
- slow-residue diffusion.

Improving barley cultivars Considerable variation exists among cultivars developed in different regions of Canada. Greater exchanges of breeding materials is recommended to fully exploit the genetic potentials of new cultivars. Environment and cultivar differences significantly affected the content of total mixed-linkage G-glucan (TBG) in barley. Breeding effort is required to decrease or increase the TBG content to meet the ideal requirements for feed-type and food-type barleys.

Disease control in beans High-density plantings of upright beans improve yields without increasing white mold disease in the crop canopy. Choosing the most appropriate cultivar is important, however, because upright lines are not equal in their ability to escape white mold.

A DNA test to detect the bean common bacterial blight pathogen (XCP) in bean seed lots was developed. As little as 100 femtograms (fg) of XCP could be detected after a 35-cycle polymerase chain reaction amplification assay. The threshold of detection could be lowered to 10 fg of DNA with two successive amplifications.

Herbicide studies on field crops Wild oat populations in parts of southern Alberta have developed resistance to triallate herbicide after 15 - 20 years of use. Growers have been advised on management strategies to control these triallate-resistant wild oats.

Five sulfonylurea herbicides were ranked in order of persistence. Cropping sequences where each herbicide may be used were identified.

The *csr1-1* gene, coding for resistance to acetolactate synthase herbicides, was inserted into *Brassica napus* canola. It did not alter

- maturity
- seed yield
- weight
- oil content.

Sethoxydim and quizalofop, but not haloxyfop and fluazifop, can be tank mixed with ethametsulfuron for combined control of grass and broad-leaved weeds in canola. Combined applications

- reduce costs
- result in more timely and cost-effective postemergence control of weeds in canola.

Combating sclerotinia in field crops The germination behavior of sclerotia, the overwintering bodies of the sclerotinia pathogen, was determined. This knowledge is important in understanding what diseases the pathogen can cause, either:

- wilt, resulting from mycelial germination
- head rot, resulting from carpogenic germination.

Normal sclerotia can survive for a long time. After storage in air dry at 20°C for 6 years, 65% of the sclerotia remained viable.

Coniothyrium minitans is better than *Talaromyces flavus* as soil treatment for controlling sclerotinia wilt of sunflower. Residues of 31 commonly used herbicides in western Canada have no harmful effects on sclerotia. Only atrazine and simazine induced the production of deformed and sterile apothecia.

Improving safflower, canola Researchers assessed cultivar interactions at 12 locations over several years, measuring

- seed yield
- percentage of oil
- days to maturity
- test weight.

They found that local environmental factors significantly influence safflower traits. Potential cultivars need to be evaluated at as many locations as resources permit.

In *Pythium*-infested soil, as temperature increased above 10°C, seedling emergence of safflower dropped to a low of 27% at 25°C. The moister the soil, the greater the infection, and the lower the seedling emergence.

The full-length sequence of the oilseed rape fructose-1,6-bisphosphatase was characterized. This sequence may prove useful in studying carbohydrate metabolism in transgenic plants.

New potato cultivars Ranger Russet potato provides the industry with a mid-season french fry variety with superior disease resistance and appearance to that of Shepody. Compared with the Idaho clone, the Amisk clone selected at Lethbridge

- produces a higher percentage of large tubers
- is less susceptible to second growth
- has superior resistance to verticillium and fusarium wilt.

Plant Breeder's Rights AC Ptarmigan, an early chipping and fresh market cultivar released by Lethbridge in 1992, was granted Plant Breeder's Rights in Canada on June 21, 1994. This is the first potato cultivar in Canada and the first Research Branch crop variety to receive Plant Breeder's Rights.

Improving potato yields In a 3-year field study, moisture stress in the early and mid season caused a greater reduction in yield and specific gravity of potatoes than did stress in the late season. Fry color was also negatively affected by early-season moisture stress.

Rimsulfuron controlled broad-leaved weeds in potato better than did existing herbicides. Its use resulted in improved yield and quality of potatoes.

Disease control in potato A DNA marker closely linked to the verticillium wilt resistance gene in tomato was identified. This DNA marker improves the accuracy of disease ratings and accelerates disease-resistance screening from several months to a single day. A similar marker is being sought in potato.

Disease control in alfalfa The two alfalfa cultivars resistant to verticillium wilt, Barrier and AC Blue J, were more productive than nine American and European cultivars in a 7-year trial. Total forage yields in tonnes per hectare were

- Barrier, 86.7
- AC Blue J, 85.5
- Beaver and Pacer (wilt susceptible cultivars), 74.4.

The verticillium pathogen in infected alfalfa seeds can be eliminated by storing seeds at 25 - 30°C under air-dried conditions for 1 year. Six Chinese cultivars of alfalfa from Inner Mongolia were tested. All were highly susceptible to verticillium wilt.

The role of seeding date and duration of fall hardening conditions on resistance to cottony snow mold was determined in first-year alfalfa. Development of compensatory growth by surviving alfalfa plants following winter injury requires more than 1 year.

Establishing forage Forage can be established in a minimum input system with no companion crop and no herbicide application, without reducing forage yield or increasing weed populations.

Freeze - thaw scarification is an effective method of increasing plant establishment when alfalfa seed contains a high percentage of hard seed.

Reproductive physiology in bees Reproduction in *Psithyrus*, a cuckoo bee parasite of bumble bees, was studied. Oocyte size of the parasite increased linearly with time, from its emergence to hibernation. The number of ovarioles per ovary varied within females and among species. As cuckoo bee body size increased, the number of ovarioles increased significantly. This information aids in understanding one of the factors limiting bumble bee populations.

Oocyte development in leafcutter bees, an effective pollinator of alfalfa, was also studied to help in timing of field placement. In leafcutters, most of the increase in oocyte volume occurred during the 2nd week after female emergence.

Biocontrol of weeds in forages Feeding damage on Canada thistle by two species of leaf beetle larvae (*Altica* spp.) was quantified by image analysis. The release of *Altica cirsicola* is being considered for control of Canada thistle. A very similar species, *A. carduorum*, has been identified by DNA analysis.

The distribution of phytophagous insects can be used to discriminate among closely related categories of plants.

Natural interactions between aphid colonies and ants on immature cottonwoods reduced beetle herbivory by 50%.

Two species of leaf-feeding beetles and a root weevil were initially released against purple loosestrife in 10 states and six provinces in the United States and Canada in 1992 and 1993. The insect biocontrol agents have successfully established at most release sites.

In perennial sow-thistle, the weed biocontrol agent *Cystiphora sonchi* requires

- immature plant tissues for gall formation
- stomata for oviposition.

Nitrotoxins The study on toxic lupines in central British Columbia showed that the two major lupine species could hybridize. The resultant alkaloid composition produces significant changes in plant toxicity to livestock.

New nitrotoxins isolated from the fruit of the New Zealand karaka tree were identified. The karaka tree is a good source of nitrotoxin standards.

Rate of return on beef research Beef research in Canada has generated a benefit-to-cost ratio of 30 to 1, after adjustment for the concomitant effects of crop research.

Reproductive performance in bulls In the absence of other clinical symptoms, prolonged dietary vitamin A deficiency

- impaired semen quality
- lowered sperm production.

However, diets with marginal long-term vitamin A deficiency or a short-term absence of vitamin A intake probably would have minimal effects on spermatogenesis.

In studies of testicular thermoregulation in bulls, temperature gradients were

- most pronounced on the scrotal surface
- small in the scrotal subcutaneous tissues
- lightly negative within the testicular parenchyma.

Induced neonatal hypothyroidism is not an effective research tool to enhance gonadal development in cattle, despite its effectiveness in other species.

Diet formulations for cattle Increasing the level of concentrate in the diet increases the efficiency of digestible energy utilization for liveweight gain.

Diet fed during selection trials does not affect concentrations of basal growth hormone or growth hormone kinetics of offspring of selected cattle. Gain and growth hormone kinetics are much more closely related to calf birth weight.

Unlike vitamin A, vitamin E is stable in the rumen environment. Diet formulations in feedlots do not have to be adjusted for ruminal degradation. A high-performance liquid chromatographic method was developed that allows rapid analysis of vitamin E in ruminal fluid.

Treating cattle feed Treating canola meal with lignosulfonate decreases ruminal digestion of crude protein without substantially increasing the indigestible protein component. Treatment methods are currently achievable in canola-processing facilities. They may markedly improve the value of canola meal as a ruminant feedstuff.

Commercial silage inoculants inhibit the development of yeast and molds in barley silage and increase the average daily gain of lambs. Since aerobic deterioration influences quality and possibly intake of silage, inoculants could be beneficial in feedlots, where exposure of barley silage to air is considerable before feeding.

In rice straw, the silica-containing outer layer of the straw is extensively disrupted by treatment of the straw with ammonia. Disruption of the protective outer layer of straw by chemical treatment expedites colonization and degradation of internal structures of this feedstuff by the cellulolytic bacterium *Fibrobacter succinogenes*.

Bloat-free alfalfa Alfalfa with a low initial rate of digestion is being selected to reduce the incidence of bloat. Alfalfa from the third cycle of selection may be most useful in offering some protection against pasture bloat under dryland cultivation, especially when water is restricted.

Ruminal microflora The growth and development of 104 isolates of fungi from wild and domestic North American ruminants were extensively studied. Light microscopic observations documented the morphological variability that exists in the four genera represented.

An alternative system for introducing foreign genetic material into *Butyrivibrio fibrisolvens* was developed. This system is a significant advancement to the genetic modification of this potentially useful ruminal organism, which is inherently resistant to electroporation, the traditional method of transformation.

The amylase gene from *Streptococcus bovis* was cloned and expressed in *Escherichia coli*. This is the first report of the expression of a feed-degradative enzyme from a ruminal bacterium in a nonruminal species. This work may lead to the eventual production of these enzymes on an industrial scale.

Expression in *E. coli* of a single xylanase gene from the important ruminal fungus *Orpinomyces joyonii* allowed investigation of its biochemical activity.

Proteolytic processing of a xylanase gene product into two separate enzymes with different catalytic properties occurs in the ruminal fungus *Neocallimastix patriciarum* 27. This finding has implications in increasing the efficiency of cloning of genes for fibrolytic enzymes in other biotechnological applications.

Marked differences in physiological responses to condensed tannins were revealed among four prominent ruminal bacteria. Tannins bind to the cell coat polymers of all these microorganisms. Their presence restricted growth and protein degradation by

- *Butyrivibrio fibrisolvens*
- *Streptococcus bovis*.

They did not affect

- *Ruminobacter amylophilus*
- *Prevotella ruminicola*.

The resistance of *P. ruminicola* may have an impact on ruminant nutrition, because this species plays a prominent role in ruminal protein metabolism.

Ruminant digestibility Scientists have studied the effect of harvest and storage on alfalfa protein structure. A large portion of alfalfa proteins are damaged by proteolysis during ensiling.

The protein matrix in the endosperm of cereal grains plays a significant role in defining its overall digestive characteristics, irrespective of grain-processing.

The starch-digesting activities of four principal ruminal fungal species were assessed against

- barley
- corn
- wheat.

Complex interactions between microbial species and grain type were revealed.

Pretreating barley straw with four common chemicals improves digestibility. This effect occurs mainly through physiochemical leaching of straw components rather than enhancement of microbial degradation.

A unique isolate of *Pseudomonas stutzeri* may have some potential for use in biochemical detoxification of industrial pollutants, e.g., mining sludge.

Controlling insect pests of cattle The centre has developed a recombinant cattle grub vaccine. Central Biotech Inc. of Swift Current, Sask., will commercialize it. Efficacy trials are scheduled to proceed in spring 1996.

Antibody response of pastured cattle to horn fly infestation maximizes within 4 weeks of fly populations reaching 150 flies per animal. However, this response is not correlated with fly abundance. Salivary antigens of the horn fly appear immunomodulatory and, as a result, are a poor choice as a basis for vaccine development.

Factors influencing diapause induction were determined for the horn fly. This information is essential for developing integrated management strategies focusing on diapause control of this pest.

Species composition and seasonal abundance of parasitoids of house and stable flies were identified in Alberta. The aim was to develop biological strategies to control the flies. Survival rates were estimated and reproductive delays were detected. Annoyance of cattle by stable flies increases with temperature and population density of the pest.

In a mouse model, parasitism and biting fly attack were shown to

- affect mate selection
- reduce spatial learning.

Parasites induce alteration of their host's neurochemical systems that influence

- health
- productivity.

A rapid, inexpensive method was developed to detect the commonly used parasiticide ivermectin. With ordinary silica gel plates and a long wavelength ultraviolet lamp, a fluorescent derivative of ivermectin could be detected in serum extracts for 3 - 4 weeks after injection of Hereford heifers with Ivomec™ at the recommended dose.

Lambs A common protozoan parasite, *Giardia*, depresses rate of gain and feed conversion efficiency.

Treatment with lignosulfonate increases the rumen undegradable protein value of both canola and soybean meals, with no adverse effects on digestibility.

Plasma IGF-1 concentrations obtained at 7 weeks of age were positively correlated with lamb growth rate, until slaughter at 45 kg body weight. Plasma IGF-1 concentrations at a young age may be useful indicators of growth rate potential in lambs.

Ultrasound is a useful tool for predicting carcass characteristics in alpine goats. It is expected to facilitate development of management strategies that improve goat meat yield and quality.

Resources

Research is conducted at

- the main centre near Lethbridge
- the research farm at Kamloops
- the field sites at Onefour, Stavely, and Vauxhall.

The main centre is located in the Agriculture Centre, a facility shared with

- the regional office of Alberta Agriculture Food and Rural Development
- Food Production and Inspection Branch of Agriculture and Agri-Food Canada.

It has an immediate land area of 500 ha. It also includes

- a 17 000-ha beef cattle ranch near Manyberries
- a 400-ha ranch near Stavely in the foothills of the Rocky Mountains
- a 130-ha irrigation substation at Vauxhall.

The Kamloops Research Farm has a land base that includes

- 57 ha of irrigated land
- 470 ha of forested rangeland
- several thousand hectares of provincial rangeland.

The staff comprises 285 full-time equivalents, including 76 in the professional categories. The centre operates with a budget of \$18.3 million from A-base resources, plus more than \$7 million from external sources.

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Klein, K.; Freeze, B. 1995. Economics of loss avoidance research on wheat in Canada. Lethbridge Research Centre, Research Branch. 54 pp.



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Mandate

The Lacombe Research Centre has a national mandate to conduct research on the processing, quality, safety, and preservation of red meats

With its affiliated sites, the centre manages breeding programs and improves crop-production systems for use in the agri-food industries of the western Parkland and northwestern Canada. Its major areas of study are

- feed and cereal grains
- pulse crops and oilseeds
- forages and forage seed
- honey bees.

The centre also develops technology for a productive and sustainable agricultural industry, managing the soil, water, and climatic resources of the region.

Achievements

- *Electronic beef grading*
- *Stress reduction in pigs*
- *Retail beef*
- *Stress susceptibility and swine deaths*
- *Hygienic beef-carass dressing*
- *Performance of forage mixtures*
- *Increased grazing with winter cereals*
- *Fall dormancy and geroplasm source in alfalfa*
- *Fertilizing forages*
- *Tracheal mites in bees*
- *Resistance to *Varroa jacobsoni* in bees*
- *Cereal breeding*
- *Barley diseases*
- *Pea desiccation*
- *Herbicide-resistant weeds*
- *Soil microbiology*
- *Tillage systems and soil quality*
- *Soil carbon*

Electronic beef grading Over the past 2 years two major trials have been completed using video image analysis (VIA) to grade beef carcasses. Taking an image of the whole side provided a more accurate estimate of actual carcass value than is currently possible. Quality traits such as marbling and meat color could be accurately measured by taking a second image on the rib eye. VIA was evaluated to determine its suitability to function at present and future line speeds in industry. VIA is expected to be adopted by the larger processing plants once the technology is commercially available.

Stress reduction in pigs Canada must maintain high standards in pork quality to remain a competitive exporter. Stress from transport and handling before slaughter degrade the quality and yield of pork. In a recent study, stress-susceptible finisher pigs were fed a diet enhanced with vitamins and minerals for 8 weeks before marketing, as well as an electrolyte therapy product for 24 h preceding slaughter. Pigs receiving the modified diets displayed better carcass traits than control animals. Nutritional modification can be effective in improving pork quality and yield.

Retail beef The desirable red color of retail beef deteriorates rapidly within a few days of commercial display. The resulting product is unacceptable to the consumer. Supplementing steer rations with vitamin E can stabilize the color of retail rib-eye steaks 2 days longer. Also, vitamin E prolongs the storage life of steaks cut from primals after 6 weeks of storage in a controlled atmosphere containing carbon dioxide. For remote markets, a predictable and prolonged color storage life is critical. The cost of vitamin E supplementation can be as low as \$4.00 a head. Potential annual savings for the retail beef industry are estimated at \$100 million.

Stress susceptibility and swine deaths A recent survey at Alberta abattoirs showed that 53% of associated swine deaths can be attributed to a genetic defect that confers stress susceptibility in pigs. Homozygous carriers of this defect were 180 times more prone to preslaughter death than noncarrier pigs, and heterozygous carriers were 5 times more so. Selective breeding to eliminate this defect could decrease the frequency of preslaughter deaths by approximately 10 000 pigs a year in Canada.

Hygienic beef-carass dressing Meat inspection authorities are moving toward mandating hazard analysis critical control point (HACCP) systems for beef-dressing processes. But to do so they need a means of objectively identifying the hygienic performance of such processes. Studies at beef-packing plants show that hygiene can be

adequately assessed by counting *Escherichia coli* in a relatively small number of swabs from carcasses undergoing dressing. Quality-assurance staff can use these methods

- to develop effective HACCP systems
- to demonstrate the degree of control being achieved over the contamination of beef carcasses.

Performance of forage mixtures The performance of alfalfa - grass mixtures varies immensely with soil and climatic conditions in the western Parkland. Smooth brome grass mixtures proved superior to meadow brome grass mixtures for hay production under moist, fertile conditions. At a drier, less fertile site, meadow brome grass gave higher dry matter yields than smooth brome grass in mixtures when weather conditions were favorable for regrowth. The same trend was observed at the moist, low fertility site, but here alfalfa was quite competitive with the brome grass. The dominance of the grass species was dependent on soil and rainfall, variables that differ greatly within short distances in the Parkland. The producer should consider the microclimate in their area when selecting species for mixtures to obtain maximum yield and quality.

Increased grazing with winter cereals Fall-planted winter cereals can provide early spring grazing. By planting as early as 15 August, spring forage production was enhanced dramatically. Rye was more effective than winter triticale and wheat for early planting in fall, resulting in grazing 3 weeks earlier in the spring. The extra 3 weeks of grazing is estimated to save \$5.00 a head over feeding stored winter feed, a saving of \$6 million in central Alberta.

Fall dormancy and germplasm source in alfalfa The genetic diversity for winter hardiness in North American alfalfa cultivars is accounted for by nine germplasm sources. At registration, the breeder assigns a fall dormancy score and the relative proportions of each of the nine germplasm sources for each cultivar. The fall dormancy score is determined by measuring plant height in October after harvest in early September. It is used to indicate cultivar adaptation for different regions.

Researchers examined the relationship between germplasm composition and plant height, the equivalence of fall dormancy. Fall dormancy fell essentially into two classes:

- a dormant category, comprising cultivars containing a large contribution of *M. falcata* and Ladak
- a nondormant category, in which Indian and African germplasm predominate.

Nine distinct classes were not recognisable, perhaps because fall dormancy class and plant height of the fall regrowth are not precisely equivalent. Breeders should recognize these limitations when using the currently assigned fall dormancy ratings to predict cultivar adaptation.

Fertilizing forages Banding urea 5 cm below the soil surface in brome grass stands did not damage the forage stand. Fertilizer efficiency was increased because the N was placed closer to the plant roots and N loss by volatilization was reduced. The same technique also increased the efficiency of P use in alfalfa.

The efficient use of P fertilizers for forage production on P-deficient soil is affected by

- rate
- method
- frequency of application.

A field trial showed that

- broadcast application was superior to band application
- a one-time application at the recommended rate at the time of seeding produced the highest yield over 3 years with half the amount of fertilizer otherwise needed to produce this yield
- the P content of the forage increased with the rate of application
- the N content decreased because of a dilution effect as dry matter production increased.

Tracheal mites in bees A laboratory kit for detecting tracheal mites in honey bee was developed. It contains a precoated ELISA plate and a monoclonal antibody. The kit is being validated by six laboratories around the world.

No direct association was found between high levels of tracheal mites in honey bees and microorganisms that might be vectored by tracheal mites. Nor were high levels of any specific organisms present in highly infested bees, compared with uninfested bees.

Resistance to Varroa jacobsoni in bees Honey bee colonies were selected for high hygienic behavior, thought to enhance their possible resistance to *Varroa jacobsoni*. In spring 1994, 10 highly hygienic colonies were selected. In April 1995, five more colonies were evaluated. These colonies were observed to uncapped and remove *Varroa*-infested worker brood. Honey bee workers expelled the adult *Varroa* without damaging them.

Cereal breeding AC Michael, a hard red spring wheat cultivar registered in 1994, is adapted to Alberta and western Saskatchewan. It has high grain yield and matures 1 day earlier than Neepawa and 2 days earlier than Laura. AC Michael has better resistance to common bunt and loose smut than Laura. AC Michael is marketed by Secan.

AC Juniper, registered in 1995 and marketed by the Alberta Wheat Pool, is a milling oat that matures 2 days earlier than Cascade. It has high yield and good lodging resistance because of its short stature and strong straw. AC Juniper is intended for

- northwestern Saskatchewan
- central and northern Alberta
- the Peace River region of Alberta and BC.

The acceptance of the feed barley AC Lacombe continues to grow, as the area planted in Alberta increased from 1% in 1994 to 5% in 1995.

Barley diseases Lacombe and the provincial government are jointly screening all western Canadian barley breeding lines for tolerance to scald and rot. Many entries have been identified. Of special interest is a group that exhibits slow scalding, showing only limited disease symptoms on the lower leaves. These lines resisted infection not through reduced spore germination but rather by reduced hyphal penetration.

Pea desiccation Many farmers are applying glyphosate as a desiccant to seed peas even though it is not registered for use. Germination and vigor of peas can be reduced, even when glyphosate is applied when the seed moisture is close to 30%. Seeds from the top pods of relatively indeterminate pea cultivars are affected the most.

Herbicide-resistant weeds Applying low rates of wild oat herbicides is not only economical and effective but can also reduce the rate of selection for plants resistant to the herbicide. Herbicide rates are selected to suppress the wild oats when the crop plants are developing. Thus the crop plants approach their yield potential, but the wild oat plants are allowed to produce some seed. Allowing herbicide-susceptible plants to reproduce can substantially increase the time until wild oat populations resistant to herbicides predominate in a field.

Soil microbiology: One hundred commercial North American legume inoculants from three major producers selling in Canada, manufactured using nonsterile peat as carrier, were tested for

- *Rhizobium* (root nodule bacteria) content
- non-*Rhizobium* biological contaminant load.

Rhizobium content and the contaminant load varied significantly. Most of the inoculants contained many more nonrhizobial organisms than they did rhizobia. Many of the contaminating organisms were capable of inhibiting rhizobial growth. Most are significant opportunistic human pathogens. Use of sterile carriers would prevent these contaminants.

Tillage systems and soil quality: Zero tillage affected aggregation and soil tilth the most in coarse-textured soils. This observation was based on measurements of

- water-stable aggregation
- concentration of soil organic matter
- differences in soil organic matter concentration among aggregate size classes.

Soil carbon: More C can be sequestered in soils by judicious use of fertilizers and reduced cultivation. The reduction of atmospheric CO₂ is important for the overall reduction of greenhouse gases that are implicated in global warming.

Resources

The Lacombe Research Centre manages a budget of \$8.2 million and a complement of 122 full-time equivalents, including 34 in the professional categories. The lead centre is located in Lacombe between Edmonton and Calgary on 808 ha of land, which has facilities for raising beef cattle and hogs. At Lacombe facilities include

- a holding barn, abattoir, blast chiller, coolers, cutting room, taste panel kitchen, and booths
- plant growth chambers, dryers, threshers, and seed storage
- laboratories
- offices.

Affiliated with Lacombe are the Beaverlodge Research Farm (BRF) and the Fort Vermilion Field Site. BRF controls 390 ha of land at two sites and rents about 35 ha of land a year for research. The Fort Vermilion field site owns 187 ha of land and rents about 3 ha of land for research. Operation is on a growing season basis only.

The centre has advisory committees reflecting research conducted at each location. Committee members comprise leaders from

- industry
- government
- universities
- commodity groups
- the farming community.

The centre supplements its resources with research and in-kind grants from provincial governments, producer groups, and agri-business. It is active in the release of plant varieties and the commercialization of technologies developed through their research.

Research Publications

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Nelson, D.L.; Rice, W.A., editors. Northern Agriculture Research Highlights 1994. Research Branch, Lacombe Research Centre. 30 pp.



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Mandate

The Summerland Research Centre conducts multidisciplinary research on tree fruits and grapes and on food science and technology for horticultural crops. Included are

- development of sustainable production systems, including soil and water resource management, control of plant growth and productivity, and improvement of fruit quality
- integrated management of pests and diseases
- cultivar and rootstock breeding and evaluation
- food chemistry, sensory evaluation, and enology
- storage and modified-atmosphere packaging
- processing technology.

Achievements

- *Disorders of tree fruits*
- *High-density production*
- *Increasing soil water*
- *Apple production*
- *Molecular studies*
- *Ginseng*
- *Evaluating grape rootstocks and varieties*
- *Breeding apples*
- *Control of powdery mildew*
- *Tree fruit entomology research*
- *Sensory evaluation*
- *Storage and packaging*
- *Processing technology and food chemistry*

Disorders of tree fruits A booklet was published containing photographs and descriptions of disorders of tree fruits; it is popular among growers and field men as a guide for diagnosing symptoms and determining remedial action.

High-density production Four years of study on peaches and nectarines have resulted in the establishment of a high-density production system that can be managed entirely from the ground. This system includes

- Siberian C rootstocks that dwarf trees, provide the highest production, and impart winterhardiness
- summer pruning to reduce the vigor of trees without reducing yields
- new herbicide combinations providing year-long weed control
- growth regulators to improve fruit quality and reduce fruit-thinning costs.

Increasing soil water Municipal biosolids and other composted organic wastes increased the water-holding capacity and buffering capacity of soil. They also increased the yield of carrots and chard. These results demonstrate the potential of organic wastes for improving the physical and nutritional conditions of coarse-textured soils.

Zeolite, a naturally occurring mineral, improved the water-holding capacity and cation-exchange capacity in sandy soils. It also increased the growth of apple trees.

Apple production In experiments on irrigation of apple trees, researchers found that

- irrigation water can be reduced by 50%, without affecting growth or yield, by withholding water at specific stages of growth
- drip-irrigated trees were smaller and had lower water potential, compared with micro-jet irrigated trees.

Growers can manipulate the yield and quality of tree fruits by timing fertilizer applications. The growth stage during which nitrogen fertilizer is applied to apple trees affects

- yield
- fruit quality
- flower development the next year.

Molecular studies A ripening-related protein and its gene were identified from cherries, and the DNA sequence was published. This protein is of the thaumatin family. It may be associated with dehydration stress or resistance to disease.

A large portion of the sequence of prune dwarf virus RNA3 has been determined. This work allows the development of a sensitive polymerase chain-reaction test to detect the virus in cherry trees.

Ginseng Research showed that

- ginseng has low demand for nitrogen
- proper temperature treatments can reduce the stratification period required for seed germination
- ginseng tolerated 2,4-D amine and MCPA amine, but not mecoprop or bromoxynil
- replant problems can be controlled by Basamid or Telone II, by pasteurization, or by soil amendments such as compost and willow leaves.

Evaluating grape rootstocks and varieties Five years of data on yield, vine size, and fruit composition showed that rootstock has little effect in the absence of biotic or abiotic stresses. One rootstock cannot be recommended over another.

Different clones produce wines with very different flavor characteristics. Wineries can use several clones to increase the complexity and value of their varietal wines.

Breeding apples A description of Sunrise apple has been prepared for publication. Sunrise is a high-quality summer apple with superior crispness, juiciness, and taste. However, limited shelf life and storage capability will affect its market potential. Sunrise apple is well adapted to northern climates, comparable to McIntosh and Red Delicious.

In trials of rootstock performance, Budagovsky 9 (B 9) and P-1 had superior performance, compared with 15 other rootstocks. Both rootstocks had better cold hardiness than the present standards, M.26 and M.7.

Cold hardiness was determined in 13 apple cultivars, many of them new varieties with no previous cold-hardiness rating. Fuji and Empire had the best hardiness, comparable with McIntosh and Spartan. The next group included Braeburn, Granny Smith, Elstar, Sunrise, Gala, and Rome. Mutsu and Jonagold were the least hardy, in the same range as Golden Delicious.

Control of powdery mildew Myclobutanil is an effective alternative to sulfur for the control of powdery mildew on cherries. These data will be used to support registration.

Tree fruit entomology research The following results were achieved:

- Methodology was developed to rear diapausing codling moth larvae. Insects can be reared in the winter and stored until release later in the season in the Sterile Insect Release Program.
- A simulation model for predicting hatch of overwintered mullein bug eggs was validated in commercial orchards.
- Neem oil administered at low doses was effective in interfering with leafroller development.
- A serological assay was developed to detect viruses in field and laboratory populations of codling moth.
- Field levels of parasitism of tentiform leafminer were determined for several species of biological control agents.
- An industry cooperator is commercializing pheromone-based mating disruption of mullein bug.
- Management of green fruit worms was improved by the use of temperature-based models to predict pest development.

Sensory evaluation A study detailing the relationship between pear fruit characteristics and sensory panel rating showed that

- optimum fruit size is 6 - 7.5 cm diameter
- bright yellow skin color is ideal, green or red skin less so
- pyriform shape is optimum, with a length-to-diameter ratio of 1.44 - 1.48

- optimum firmness is 27 - 30 N
- acceptable soluble solids concentration range between 13.6 and 17.2 °Brix
- the balance between sweet and sour is a useful indicator of fruit quality.

Sources of variation in data on apple flavor and texture have been described using novel statistical analyses.

Storage and packaging Acetic acid applied as a vapor to grain prevented the growth of storage molds such as *Aspergillus flavus*, while maintaining seed viability.

Bacteria from apple fruit, primarily *Bacillus subtilis*, were effective biocontrols of fungi that cause postharvest decay.

Modified-atmosphere packaging combined with acetic acid fumigation extended the shelf life of strawberries and grapes.

Processing technology and food chemistry A new multi-membrane filtration test unit was designed, assembled, and commissioned for the production of fruit juices. This work was part of a collaborative research project with industry.

Technology for replacing xanthan gum with flaxseed gums in bakery products has been transferred to private industry.

Studies were done on the effects of blanching on apple slices. Storing dried fruit at water activities below 0.6 may result in reduced browning during storage.

Technology for extracting juice from several types of fruit using the decanter centrifuge has been developed.

The quantification and distribution of simple and acylated anthocyanins from blueberries and sweet cherries have been described.

The chemical structure, molecular size distribution, and rheological properties of hydrocolloidal gum from flaxseed have been described.

Resources

The centre, located near Summerland in the Okanagan Valley, has a modern office and laboratory complex complete with pilot plant facilities for food research. Research on tree fruit production and protection is also done at the research farm in Kelowna. The centre proper resides on a land base of 320 ha, of which approximately 90 ha are irrigated and available for tree fruit and viticulture research. The staff comprises 77.8 person-years, including 25 research scientists, and operates with a budget of \$5.2 million.

Research Publications

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Mandate

The Pacific Agriculture Research Centre (PARC) conducts multidisciplinary research of significance to agricultural crops, at the cellular and molecular levels, on

- viruses
- bacteria
- fungi.

Integrated management controls are developed for

- nematodes
- insect pests
- plant diseases.

The centre breeds new cultivars of raspberries and strawberries and develops production systems for

- poultry
- dairy
- forages
- small fruits
- field and greenhouse vegetables.

Soil and fertilizer management systems are developed for the coastal region of British Columbia.

Achievements

- *Tomato ringspot nepovirus movement and coat proteins*
- *Plant subgenomic RNAs*
- *Engineering resistance to plant parasitic nematodes*
- *Detection of Phytophthora species*
- *Viruses detected in plant guttation fluid*
- *Pheromone mating disruption of blackheaded fireworm*
- *Ground water contaminants*
- *Varieties released*
- *Potato late blight forecasting system*
- *Integrated pest management (IPM) video*
- *Geographic information system*
- *Biological control of twospotted spider mites*
- *Greenhouse vegetable pest*
- *Greenhouse tomatoes*
- *English cucumbers*
- *Plasticulture production system*
- *Weed control in herbs and vegetables*
- *Soil nitrogen management*
- *Animal waste management*
- *Forage potassium levels*
- *Lean-to-fat composition of live birds*
- *Poultry diets*
- *Poultry behavior*

Tomato ringspot nepovirus movement and coat proteins Tomato ringspot nepovirus (TomRSV) infects small fruits and tree fruits. Coat and movement proteins of TomRSV are expressed coordinately via proteolytic processing of a polyprotein precursor at specific cleavage sites by a virus-encoded protease. Therefore the two cleavage sites involved in the release of the coat and movement proteins from the precursor polyprotein must be recognized at equal efficiency by the TomRSV protease. These results provide important information toward the design of inhibitors of viral proteases, which has potential as a novel strategy for engineering resistance to plant viruses.

Plant subgenomic RNAs The complete replicative cycle of many plant and animal viruses requires the synthesis of less than full length viral subgenomic RNA promoters. These sequences act as templates for the production of viral-encoded protein. They have not been well studied in viruses of the supergroup II.

To help fill this gap, the promoter sequence in cucumber necrosis virus was analyzed for the subgenomic RNA that is responsible for the synthesis of

- the viral cell-to-cell movement protein
- a protein involved in symptom formation in the host plant.

This promoter was found to have few similarities to other viral subgenomic RNA promoters. Understanding how viral RNAs are synthesized aids in the development of new strategies for protecting plants from viral infections.

Engineering resistance to plant parasitic nematodes Proteinase activity was monitored throughout the development of the northern root-knot nematode. Two cysteine inhibitors from rice almost completely inactivated the proteinase under natural conditions. Expression of rice cysteine inhibitors in transgenic plants may delay or inhibit the development and reproduction of plant parasitic nematodes.

Detection of Phytophthora species DNA probes were developed to identify the main *Phytophthora* species found on small fruits. The probes were tested by reverse dot blot with a collection of plant isolates. *Phytophthora* species were correctly identified from inoculated roots and from frozen infected root samples from previous years. This new technology will be used to identify fungal pathogens in relation to certification of small fruits.

Viruses detected in plant guttation fluid Viruses from 10 different groups were detected by electron microscopy in cucumber guttation fluid from systemically infected plants. Positive ELISA readings and infectivity were demonstrated for most viruses. This phenomenon indicates the broad potential for plant xylem tissue to act as a conduit for virus transport. A probable source of virus is immature vessels in roots of infected plants. The occurrence of viruses in guttation fluid is a novel escape route to aid dissemination without vectors or damage to plants.

Pheromone mating disruption of blackheaded fireworm Blackheaded fireworm is a major pest of cranberry. Synthetic pheromone released from dispensers placed throughout a cranberry bog disrupted the normal mating of the adult moths. This pheromone mating disruption technique has potential for control of this pest without the use of chemical insecticides.

Ground water contaminants A 4-year collaborative study with Environment Canada on ground water of the Abbotsford aquifer showed trace levels of a new contaminant, 1,2,2-trichloropropane. The probable source of this contaminant was an impurity in soil fumigants, Telone and Telone II, widely used for control of pathogenic nematodes in small fruit production. No health advisory has been established for the new contaminant; however, its toxicological effects would have been reflected in the evaluation of Telone and Telone II. This study resulted in withdrawal of Telone II in the Lower Fraser valley, thus protecting the ground water from further contamination.

Varieties released Two new cultivars were released:

- Qualicum raspberry
- Nanaimo strawberry.

Qualicum is

- adapted to processing
- well suited for fresh market
- superior to Tulameen for long-distance shipping
- similar to Chilliwack but produces larger, firmer fruit and higher yields.

Nanaimo should help to diversify strawberry varieties for British Columbia, being

- suitable for both fresh and processed market outlets
- more resistant to the red stele root rot than the standard variety Totem.

Potato late blight forecasting system Programming of a late blight forecasting system has been developed to cope with new problems associated with the introduction of the A2 mating strain. The program can be operated by growers or private consultants using manual or electronic weather recorders. The program

- selects the most appropriate fungicides
- schedules for optimum control of late blight.

Integrated pest management (IPM) video An integrated pest management program has been developed for the major insect and disease problems of potatoes in British Columbia. Private integrated pest management consultants have implemented the program in over 60% of plantings. Pesticide use has been reduced by 80% as a result. A

video was produced to assist private integrated pest management consultants in scout training and grower awareness to

- help improve the skill level of scouts
- ensure program quality between companies.

Geographic information system Integrated pest management (IPM) programs in British Columbia are being improved with the use of geographic information system (GIS) computer technology. By mapping annual land use and pest information for major growing regions, novel integrated pest management strategies were developed for several new potato pest problems. For example, GIS procedures were developed to forecast where potato insects and fungal and viral diseases will be before the next growing season. The procedures develop hazard maps that growers or private integrated pest management (IPM) consultants can use to manage pest problems before they occur.

Biological control of twospotted spider mites Twospotted spider mites are important pests of many field and greenhouse crops. Earlier studies showed that a native predator, *Amblyseius fallacis*, had potential as a biological control agent. A collaborative 3-year study was done with producers, pest managers, and a company to scale up commercial production of the predator. The mite was successfully controlled on 100 ha of strawberries. The biocontrol company plans to triple production of the predator, with sales internationally. Development of a predator - prey population dynamics model was a key factor in the success of this biological control system.

Greenhouse vegetable pest Pest management strategies are being developed for *Echinothrips americanum*, a new pest in the greenhouse vegetable industry. Color traps may prove useful for monitoring. Some of the natural enemies in use in the greenhouse industry might be used for biological control of this pest.

Greenhouse tomatoes Increasing the concentration of hydroponic nutrient feed for greenhouse tomatoes increased

- fruit soluble solid content
- titratable acidity
- vitamin C content.

Levels of volatile compounds were unaffected. Fruit volatiles were found to increase with redness during ripening. This increase was the same for on-vine or harvested fruit, as long as harvested fruit had first reached the breaker stage.

English cucumbers The shelf life of long English cucumbers was improved by training the plants to a more open canopy. This growth habit increased

- light intensity
- ratio of red to far-red light reaching the fruit.

The effect was

- to increase green fruit at harvest
- to reduce incipient yellowing after harvest.

Plasticulture production system A new plasticulture production system was developed for annual globe artichoke. The intensive system incorporates research findings on water and nutrient requirements in

- fertigation
- planting density effects
- response to plasticulture.

The system produces large high-quality buds at yields of about 15 t/ha. Plasticulture systems are also being developed for culinary and medicinal herbs. A new repository for medicinal plant germplasm is being established at PARC.

Weed control in herbs and vegetables An organic weed control strategy has been developed and tested on medicinal and culinary herb crops whose market has a low threshold for contamination with weeds. Composted vegetable waste was used as a high-salt mulch, which effectively suppressed weed emergence.

Combinations of tillage, barley cover-cropping, and herbicide management were evaluated for broccoli and cauliflower production. Results were as follows:

- weed emergence was stimulated by tillage and by cover-cropping
- the species stimulated depended on tillage and herbicide treatments
- cauliflower grew better after cover-cropping despite higher weed competition
- broccoli growth was suppressed.

Soil nitrogen management Improving nitrogen management is a priority in reducing contamination of surface water, ground water, and the atmosphere. Newly developed soil nitrate tests for both maize and raspberries are being adopted by producers, in order to

- reduce the risk of nitrate leaching
- cut down fertilizer costs.

A new intercropping system

- reduces nitrate leaching from corn land
- prevents erosion in winter.

It produces a net economic gain and is being evaluated by several farmers.

Considerable advances have been made in clarifying nitrogen processes and transformations in the soil, including

- mineralization and immobilization
- crop uptake
- denitrification
- ammonia volatilization
- nitrate leaching
- nitrate adsorption by soil particles
- clay fixation of ammonium.

This new information is being integrated by computer simulation and is influencing the development of new management methods. The information has led to conceptually new approaches for assessing environmental impact.

Animal waste management Studies on use of manure on corn land have lead to recommendations for producers that will

- reduce nitrate leaching
- lower loss of ammonia and nitrous oxide to the atmosphere.

New technology for applying manure on grassland, adapted from Europe, promises to significantly reduce nitrogen losses from dairy farms. It is now being considered by the industry.

New studies were initiated on feeding strategies to minimize excess nitrogen excretion by chickens and cows and to capture ammonia from litter in poultry barns. With industry partners methods are being developed for

- enhancing the composting process
- producing novel products and uses from compost.

Forage potassium levels High levels of potassium in home-grown forage

- have a negative impact on the utilization of calcium and magnesium by dairy cows
- predispose the cows to an increased incidence of milk fever and grass
- increase urine volumes
- change the mineral content of the urine
- possibly cause kidney stress.

The use of sodium as a fertilizer was reputed to reduce potassium uptake by forage. However, a field trial carried out over the past 2 years has failed to demonstrate any significant influence. Various grass species do take up magnesium and potassium at different rates. Cultivars of tall fescue have higher levels of magnesium and lower levels of potassium, compared with varieties of orchard grass and rye grass.

Lean-to-fat composition of live birds An electromagnetic scanner has been employed as a noninvasive measure of the lean-to-fat composition of live chickens. The scanner has been validated with laboratory measurements of carcass composition. The system is accurate in estimating lean body mass but has been less successful in predicting fat content.

Poultry diets Purified amino acids have been used in broiler diets, in order to

- balance specific amino acid requirements
- reduce the total nitrogen intake.

The effects of processing methods and enzyme supplementation on the birds' retention of nitrogen have also been determined. Enzyme supplementation improves the retention of nitrogen and phosphorus, thereby reducing the amount excreted and the impact of the broiler manure on the environment.

Poultry behavior A study was conducted on laying pullets throughout a 6-month rearing period to determine the effect of group size on

- feather pecking
- aggression
- behavioral synchronization
- use of perches.

Scientists hope to find the cause of behavioral problems in aviary housing systems for laying hens with the goals of

- reducing cannibalism
- improving egg quality.

Another experiment studied the effects of cover, group size, food distribution, and simulated attacks by aerial predators on the aggression and space utilization of free range broilers. The project assessed the practical value of providing cover to enhance indoor and outdoor space used by chickens under commercial conditions.

At Agassiz, scientists studied

- the influence of perch spacing on perching behavior by laying hens
- the impact of new dimmable fluorescent lighting on broiler production and health using the new automated feed and body weighing equipment.

Collaborative experiments were conducted, in order to

- assess the use of an electromagnetic scanner to measure chicken body fat
- determine the effects on chicken fat deposition of lighting pattern, diet, and a low barrier between the food and water.

Resources

PARC comprises two research sites, at Vancouver and Agassiz. The Agassiz research site was established in 1886, as one of the five original experimental farms established under the Experimental Farm Act. PARC operates two field sites at Agassiz covering 665 ha and two at Abbotsford covering 16.5 ha. The Vancouver research site is located on the campus of the University of British Columbia. Many PARC staff hold adjunct professor status, and research facilities are provided for graduate students, visiting scientists, and postdoctoral fellows. The staff consists of 103 full-time equivalents, including 34 professionals. PARC manages a budget of \$6.9 million.

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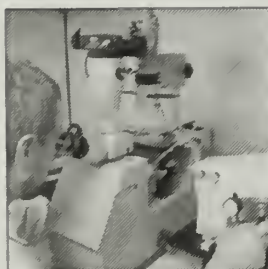
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